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ERRATA

Page 106. Soil type D shown on the colour plate facing this page should be spelled, Vergenness.

Page 113. The second sentence in the section on "Marketing" should read, "As long as such diversities exist success in any form of cooperative selling is impossible."

Page 150. The second line of the heading of table 19 should read "*reaction in the cross Marquillo* × *H-44-24*."

Page 158. The caption under figure 1 should read, "Right to left: Khapli, Pentad, H-44, Hope, Webster."

Page 277. In the tabulation below the middle of the page, the figure in the "Country Elevator to Ocean Cargo" line in the Manitoba column should read, " – 0.64%".

Page 284. Table 5.—in the column for the 10th month the 6th item from the top should read, "60.11."

Page 285. Table 6.—in the last column, the fifth item from the top should read, ".87 ± 0.515".

Pages 402 and 484. Add the following footnote:

"Gratitude is expressed to Dr. D. L. Bailey, of the University of Toronto, for his valuable criticisms and advice during the course of this investigation; also to Dr. L. C. Coleman, formerly of the University, for his helpful suggestions in the early stages of the problem. Thanks are also due to Mr. E. F. Palmer and his staff at the Provincial Horticultural Experiment Station, Vineland, and to Dr. G. H. Berkeley of the Dominion Laboratory, St. Catherines, for their co-operation in connection with time and materials."

Pages 430, 432 and 434.

In tables 1, 3 and 4 on these pages, the formula for securing P.E. should read in each case "P.E. $= \pm .6745 \frac{1 - r^2}{\sqrt{N}} = \pm$".

Page 434. In table 4 the first formula in the 4th line should read "$\Sigma Y\ (M\ Y) = 793{,}628.9$".

Page 442. In table 20 the formula for the "coefficient of association" should read

$$\frac{2 - 20}{\sqrt{6 \times 6 \times 5 \times 7}} = \frac{-18}{\sqrt{1260}} = -0.51"$$

Page 546. To table on "*Nematode population of certain North China soils*" add a footnote as follows, "Nematodes in the soil – H. D. Brown, Lingnan Science Journal, Vol. 8, December 1929".

Page 621. For date in title read "1929".

SCIENTIFIC AGRICULTURE

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THE PROPAGATION OF APPLES BY MEANS OF ROOT CUTTINGS[1]

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[Received for publication March 10, 1931]

Introduction

There are at least three possible initial methods of producing apple varieties on their own roots:

1. Layering. Rooting occurs on young shoots up to and around which soil has been mounded.
2. Long scion-short piece root grafts. When planted deeply roots frequently arise from the variety scion.
3. Stem cuttings.

After varieties are obtained on their own roots by any of these methods there remains the possibility of increase by root cutting propagation.

There are several reasons for attempting to secure apple varieties on their own roots:

1. *Resistance to freezing.* Potter (*6*), Chandler (*7*) and others have shown that certain variety roots are hardier than the average run of seedling roots now in common use as stocks.

2. *Uniformity in behaviour.* There is reason to believe that varieties on their own roots or on roots of a clone should be more uniform in growth and yield than varieties grafted on miscellaneous seedling stocks (*1*).

3. *Resistance to water, nutrient, and food transfer offered by a graft union.* There is always some irregularity in structure at a union which is almost certain to cause resistance to flow of water, nutrients or food. In trees on their own roots there is no such possible obstruction.

4. *Resistance to disease and insects.* For many years in Australia and elsewhere Northern Spy roots have been used as a stock because they offer marked resistance to woolly aphis. Fromme (*9*) has shown that Spy roots show in addition to resistance to woolly aphis a certain amount of resistance to the Black Rootrot disease.

Theoretically, stem cutting propagation is the most attractive of the above three initial methods since individuals can be closely planted and require little handling resulting in conservation of space and time. Practically, however, results with stem cuttings of apple varieties have been largely unsuccessful.

Before the initiation of this investigation Yerkes (*20*) had shown that one year apple seedlings would propagate readily from root cuttings. The question arose, could varieties be so propagated? The root cutting method

1 A thesis submitted to the faculty of the University of Maryland in partial fulfillment of the requirements for the degree of Doctor of Philosophy, June, 1929.

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offered the same advantages in space and time conservation as did the stem cutting method.

In the spring of 1926 there was available at the University of Maryland four varieties on their own roots, viz., Stayman, Delicious, York and Wealthy. Auchter (*3*) had obtained these trees on their own roots by the long scion-short piece root method. After two seasons' growth these trees had been dug on December 15, 1925, and were heeled in outside over winter. The variety roots of these trees were one and two years old. They were severed from the trees, cut into 2-3 inch sections, and on March 12, 1926, planted in the greenhouse in sand and in a half and half mixture of peat moss and sand. At the same time root pieces of one year French Crab seedlings were planted. The variety root pieces were almost a total failure while the French Crab root pieces under the same conditions were almost a perfect stand and grew well.

Statement of Problem

Studies were then commenced to determine, (1) the reason for the difference in propagation behaviour between the one year old French Crab seedling roots and the one and two year old variety roots, and (2) under what conditions variety root pieces could be successfully propagated.

Review of Literature

The literature pertaining to root cuttings will be briefly reviewed. Shaw (*17*) grafted variety stem scions on root pieces of six varieties. Some of the latter were three or four years old. These grafts resulted in a very poor stand and those that did grow did not do as well as similar grafts on one-year seedling roots, i.e., regular nursery grafts. Apparently no attempt was made to grow these variety root pieces by themselves. However, a certain amount of success was attained in using seedling root pieces from young trees while seedling roots from older trees were almost a complete failure. R. G. Hatton of East Malling Research Station, England, in a letter to the writer, dated December 16, 1926, gives the following results on variety root cuttings. Only small numbers were used in each case:

Lord Derby gives about 30 per cent successes and good plants result.

Cox's Orange Pippin gives about 25 per cent successes but only makes poor trees.

Bramley's Seedling gives less than 20 per cent successes and the trees are only mediocre.

Yerkes (*20*) states, "By far the best results are being secured by beginning propagation from one-year old trees. Cuttings from two-year and older roots give poorer stands and also tend to form undesirable root systems. Cuttings from roots of mature apple trees often form leaf buds, then fail because new roots do not develop." This quotation refers to seedling roots only. In a later paper (*21*) he deals with variety roots saying, "Roots emanating from the scions of named varieties when used for cuttings have usually given poor stands through failure of new roots to grow, though adventitious leaf buds have often formed and a little growth has started." In this same paper a table of results with variety root cuttings is given. These were planted April 4 and notes made June 1.

It is not clear whether the figures express the number of plants having a top with leaves or the number of plants with new roots. The writer has had root cuttings maintain a top with turgid leaves for three or four months and still no new roots would form. If the plants do not form new roots they are useless.

Bregger (*5*) obtained very poor results when he grafted McIntosh and R. I. Greening stem scions on roots taken from six year old McIntosh trees on seedling stocks. He found that the seedling stocks produced new roots in only a few instances.

G. F. Potter of the University of New Hampshire writes (letter to the writer dated May 8, 1926) that he obtained Hibernal roots from deeply planted long scion-short piece root trees. He grafted these Hibernal roots using as scion varieties, Baldwin, McIntosh and Wealthy. He says, "Unfortunately none of the trees in the nursery where this stuff was planted have done well but those on the Hibernal roots appear to compare favorably with any in the nursery."

At the U. S. Department of Agriculture Station at Shafter, Calif., they seem to get good vigor from at least some variety root pieces, for the pomologist, Mr. L. B. Scott states in a letter to the writer dated May 18, 1927, "We secure a top growth of four to five feet in one season from varietal root cuttings and from our root cutting propagation from selected seedlings, which we have carried through three vegetative propagations, we secure a growth of from six to eight feet in one season." At Shafter they plant in December or January in the open and give furrow irrigation about once a week in spring and early summer. Winter temperatures are quite uniform and summer temperatures very high.

To summarize the literature, it appears that varietal root cuttings and root pieces from older seedling trees usually make a poor stand and the ones that form new plants grow very slowly. The rapid growth conditions of California seem to give better results with root cuttings than are obtained in the East. Potter's results were with the crab Hibernal which may give different results than one would get with our standard commercial varieties.

Methods and Materials

For the sake of clarity and to facilitate presentation the methods are discussed under each separate heading in the development of the thesis.

The variety roots used in this investigation were obtained mostly from own-rooted trees resulting from the long scion-short piece root method or from layers. A few roots were used from trees obtained on their own roots by root cuttings but none from trees obtained by means of stem cuttings. In the latter stages of the investigation roots were secured from ten and eleven year old variety seedlings. One year French Crab seedling roots were used as a check in all propagation tests and occasionally they were supplemented with one year Spy and Tolman seedling roots.

Presentation of Data

The report on experimental work will be given under the following headings and sub-headings:

A—Field and Greenhouse Work
1. Root Cuttings
2. Nursery Grafts
3. Root Piece Grafts

B—Laboratory Work
1. Carbohydrate Analyses
2. Amylase
3. Catalase
4. Respiration
5. Anatomy
6. Water Relations
7. Chemical Stimulation

A. Field and Greenhouse Work

Root Cuttings

Attempts have been made to grow apples from root cuttings since March 1926. The first two seasons at the University of Maryland numerous variety roots were planted. During the past two seasons at the Ontario Horticultural Experiment Station both variety roots and seedling roots from older trees have been used.

Variety roots were taken from trees ranging in age from two to four years and the root pieces themselves ranged from one to four years. Pieces were 5 to 7 cm. long and 0.2 to 2 cm. in diameter and were planted in soil, pure sand, pure peat moss and sand-peat moss mixtures, mostly the latter, both in the greenhouse and in cold frames. Planting was done during the winter and spring. Some cuttings were planted in the horizontal position but the largest number of them were placed upright in raised greenhouse benches. They were planted just deep enough to be covered in the medium. Bottom heat was given only occasionally and no attempt was made to control the temperature other than to prevent extremes likely to be harmful.

Sand and sand-peat mixtures seem to be equally good as a medium but limited results on peat moss alone show poorer results since there is a greater tendency for the root pieces to mould and rot. Planting the root pieces upright gave just as good results as horizontal planting and, because it resulted in a better use of space, the former method was used almost entirely.

Very poor results have been secured from variety root pieces and seedling root pieces from older trees, regardless of the age of the root piece itself. The small percentage which produce roots grow very slowly. *Most of them produce buds freely but new roots fail to emerge* and therefore the plants remain at a standstill for a long time and eventually die. On the other hand root pieces from all one-year old apple seedlings give a high percentage of rooted plants which grow very vigorously and produce excellent new root systems. These results are in accord with those of Yerkes, already mentioned. Yerkes has some of his selected seedling clones now in the fifth and sixth year of propagation from root cuttings and there has been no lessening in vigor. In the experiments being reported here, one-year Kansas-grown "French Crab" were used as a check on the variety root cuttings. "French Crab" is really a misnomer since the seed is gathered from French cider apples. These seedlings have a long straight tap root which make three or four root cuttings per plant.

TABLE 1.—*Results from variety and French Crab root cuttings.*

Lot	Year	Place Planted	Source of cuttings	Number of varieties	Total number planted	Total No. producing new roots	Per cent producing new roots
A	1925–26	Greenhouse	U. of Md. long scion trees	4	786	18	2.3
B	1925–26	"	U.S.D.A. (Md.) trees from layers and root cuttings	9	341	0	0
C	1925–26	Cold frame	U. of Md. long scion trees	4	1217	1	0.08
D	1925–26	"		Fr. C. Sdlg.	170	142	83.5
E	1925–26	Greenhouse		"	145	113	78.0
F	1926–27	"	U. of Md. long scion trees	2	74	0	0.
G	1926–27	"	U.S.D.A. (Md.) trees from layers and root cuttings	24	858	31	3.6
H	1926–27	"	U.S.D.A. (Calif.) trees from root cuttings	14	381	139	36.5
J	1926–27	"		Fr. C. Sdlg.	20	16	80.0
K	1926–27	"	from plants of Lot A which grew 1 year	1	21	9	42.9
L	1926–27	"	from plants of Lot E which grew 1 year		21	13	61.9
M	1927–28	"	U.S.D.A. (Md.) and U. of Md. trees	29	803	84	10.5

It is this material that many nurserymen use as a stock for budding and grafting apples. The roots are frequently as thick as 1 cm. in diameter at the top end.

Table 1 shows the difference in propagation behaviour between roots from one year French Crab seedlings and variety roots. By comparing lots A, B, C, F, G and M with lots D, E and J the difference in response between variety and one-year French Crab root pieces is quite evident. One year Tolman and Spy seedlings gave results equally as good as the one-year French Crab. Material obtained from the U.S.D.A. station at Shafter, Calif., lot H, gave, in the aggregate, a somewhat higher percentage of plants but there was a gradation in response among the 14 varieties from 0 to 90 per cent stand. The two varieties, Grimes and Duchess, which gave the best results, were, by means of leaf characters, subsequently found to be untrue-to-name. Apparently both were clones, the Grimes appearing crab-like in growth characters. There were some Stayman plants obtained from root cuttings in the spring of 1926 (plates 1 and 2) which grew new roots of sufficient size for cutting into pieces a year later. These were planted beside comparable French Crab root pieces, also from the plants of previous season's growing (lots K and L). These pieces were only 2 to 3 mm. in diameter and yet a relatively high percentage rooted, though all grew slowly. This suggests that if one could so invigorate the few variety cuttings which do grow it might be possible to grow plants successfully from root pieces taken from such parent plants. The material obtained from Shafter, Calif. substantiates this belief. These roots were taken from one-year old plants obtained from root cuttings which apparently had grown rapidly since there were some roots more than 1 cm. in diameter.

Plate 1.

4 Stayman plants grown from root cuttings in 1926. They were planted in the greenhouse, March 12 and transplanted to the cold frame, May 31. Picture was taken the spring of 1927 when the plants were one year old. At this time root pieces were taken from these plants and grown in the greenhouse (Lot K of table 1).

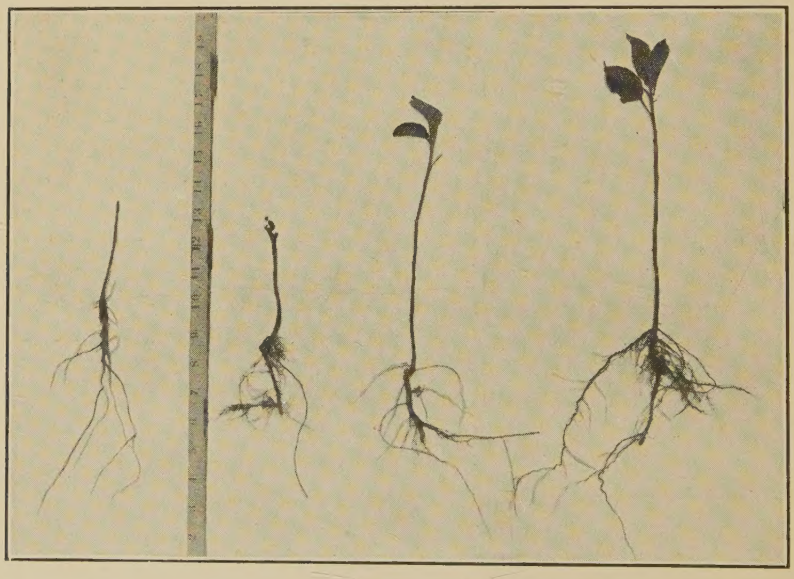

Plate 2.

4 Stayman plants grown from root cuttings in 1926. They were planted in the greenhouse, March 12 and transplanted to the cold frame, May 31. Picture was taken the spring of 1927 when the plants were one year old. The 8 plants of Plates 1 and 2 were the only ones obtained from several hundred Stayman root pieces planted in the greenhouse, March 12, 1926.

On October 25, 1927, a ten year old McIntosh seedling tree was dug up. All the roots were cut into pieces and planted in a sand-peat moss mixture, 2 to 1, in an open raised bench in the greenhouse. In about three weeks time shoots bearing small leaves appeared above the surface. These grew slowly or remained at a standstill for months. May 18, 1928, they were dug up and examined. At this time many of the shoots had died and the tallest living one was not over three inches in height. Only about 10 per cent of the 233 cuttings were rooted and then only poorly. There was no consistent difference in response between the root pieces of one root and another or with respect to distance from the trunk axis or age of the root piece itself. Apparently the age of the tree is the factor determining success or failure and not the age of the root piece itself. Roots from several other McIntosh seedlings as well as Golden Russet, Wealthy and Duchess seedlings, all ten or eleven years old, gave results similar to those mentioned above. Root pieces from these older seedling trees have been planted at various times from September to May with similar results. At no time has there been any indication of a rest period such as affects the tops of trees which is in accord with the investigations of Harris (*11*). This eliminates the difficulty of breaking the rest period which is necessary if one wishes to start apple stem cuttings in the late fall or early winter months.

2. *Nursery Grafts on One-year French Crab and Variety Root Pieces*

In the spring of 1926 some of the larger variety scion roots, similar to lots A and C of table 1, were bench grafted with stem scions of several varieties and planted directly in the field with checks comparable in size made up of the same scion varieties on one-year French Crab seedling root pieces, i.e., ordinary nursery grafts. In the spring of 1927 this experiment was repeated, except that variety root pieces used were from the U.S.D.A. Station at Glendale, Md., being taken from trees obtained on their own roots by means of layers and root cuttings, similar to lot G of table 1. In both years the variety root pieces showed poor callusing at the union and little activity while the French Crab pieces (checks) gave all indications of a quick start into growth. As might be predicted from the results on straight root cuttings just given, the grafts on variety root pieces were a near failure while the check was about an average nursery stand (see plate 3).

TABLE 2.—*Bench grafts planted in field. Variety and Fr. Crab seedling root pieces as stock and variety stem pieces as scion.*

Year	Number of Varieties as stock	Number of Varieties as scion on each stock	Total Number of grafts where variety root is stock	Rooted on stock		Total Number of grafts where F. C. Sdlg. root pc. is stock	Rooted on stock	
				No.	Percent		No.	Per cent
1926	3	6	136	5	3.7	136	87	64.0
1927	12	2	197	8	4.1	53	46	86.8

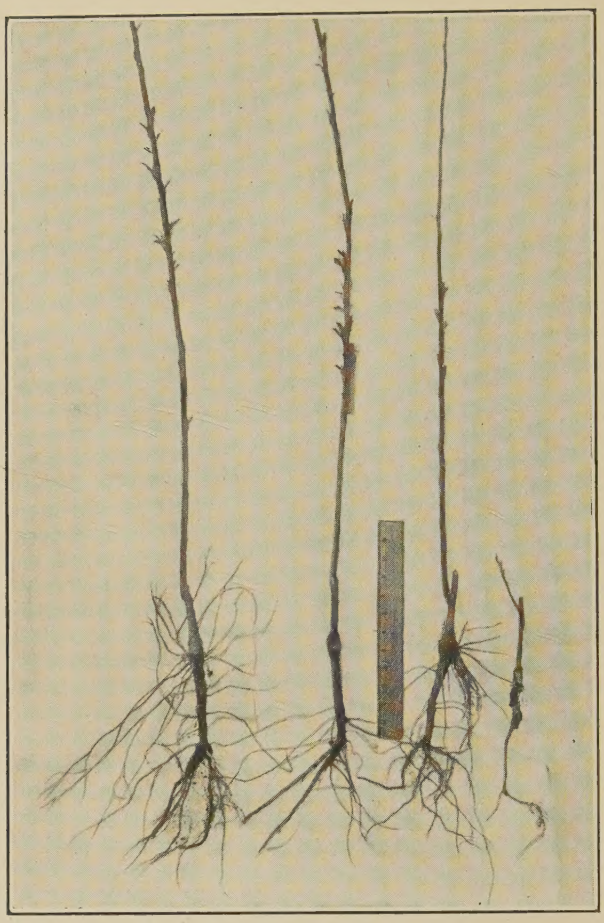

Plate 3.

1926 field grafts.

Picture taken April, 1927.

Left to right—

1. Delicious stem top—Fr. Crab Sdlg. root
2. Delicious stem top—Stayman root
3. York stem top—Fr. Crab Sdlg. root
4. York stem top—Stayman root

Nos. 2 and 4 are two of the field grafts on variety roots which grew. Nos. 1 and 3, respectively, are their checks on Fr. Crab Sdlg. roots.

3. *Root Piece Grafts*

Reciprocal root piece grafts between varieties and one-year French Crab were tried. Grafting roots on roots is an unusual procedure and in fact the writer knows of no record of this kind of a graft. However, it was found that it could be done successfully. Table 3 shows there was no advantage in using a "nurse" root but there appears to be some promise in using a "nurse" top. Unfortunately rot took a heavy toll in 1927 and spoiled results but in 1928 the grafts remained perfectly healthy.

At this time over 55 per cent of the variety root pieces formed new roots when, without the "nurse" top (French Crab), only 6 per cent became established (plates 4-7). Apparently the "nurse" top contributed something to the variety root piece below it which induced it to root. This finding together with the fact that some of the variety root pieces form new roots convinced the writer that the trouble was not a fault of internal anatomical structure but of inadequate nutrition. It is much more likely that the "nurse" top changed the nutrition of the stock piece below it than that it changed the structure. It has not yet been determined if, when the top piece is cut away, the variety root piece will form buds to make a new top and so become an established plant. In any case, this is such an involved procedure that it is of physiological interest rather than of commercial importance. Halma (*10*) got similar results with citrus roots from old trees using a leafy citrus shoot as a "nurse" top.

TABLE 3.—*Root piece grafts in greenhouse. Medium—sand-peat moss mixture. Stock and scion each about 2 inches long.*

Year	Scion	Stock	Total No. of grafts	Variety pieces rooted	Remarks
1927	8 varieties	1 yr. Fr. Crab	48	0	Severe attack of rot
	1 yr. Fr. Crab	8 varieties	48	9	" " "
1928	1 yr. Fr. Crab	8 varieties	54	30	Healthy

B. Laboratory Work

1. *Carbohydrate Analyses of Roots*

Method. *Sampling.* In all carbohydrate analyses 10 gm. samples of roots were used. Four to eight pieces of roots of propagation size were required to obtain the necessary weight. In some tests sampling was random but in others the treated pieces were alternate with the check pieces on the same roots, the latter being cut into 2-3 inch sections as for propagation.

Extraction. After being weighed the root pieces were cut up with the pruners into discs not more than 2 mm. in thickness, put into an erlenmeyer flask containing 0.25 gms. of precipitated calcium carbonate, 50 c.c. of boiling 95 per cent alcohol added, brought to a boil and 30 c.c. of hot water added. With a funnel covered by a watch glass as a condenser the preserved roots were boiled in water for one hour.

Reducing Sugars. The extract was then filtered off from the solid pieces, heated slowly to evaporate the alcohol and until the volume was reduced to about 50 c.c. The solution was cleared with a slight excess of lead subacetate and the excess lead removed with sodium carbonate after which the solution was made up to 250 c.c., 50 c.c. of which was used in determining reducing sugars by the Allihn method.

Total Sugars. Another 50 c.c. portion was put into a 100 c.c. volumetric flask, 5 c.c. of concentrated hydrochloric acid added and the

Plate 4.

Root piece grafts, taken April 5, 1928. French Crab seedling on French Crab seedling.

Plate 5.

Upper—Root piece grafts—French Crab seedling on R. I. Greening.

Lower—R. I. Greening root pieces not grafted. Note that there are no variety roots in the latter while there are 4 out of 7 rooted in the former. Picture taken April 5, 1928.

Plate 6.

Root piece grafts, taken April 5, 1928. French Crab seedling on Ben Davis. Note both scion and stock rooting.

Plate 7.

Root piece grafts, taken April 5, 1928. French Crab Seedling on Baldwin.

mixture kept at 70°C on the water bath for fifteen minutes to invert the sugars. The mixture was neutralized with sodium carbonate powder, made up to volume and total sugars determined.

Starch. The solid residue from the sugar extraction, which had been washed free of sugars, was dried in watch glasses over the steam bath. After grinding in a mill 100 c.c. of water was added. The mixture was boiled for twenty minutes to gelatinize the starch, cooled, and taka-diastase solution added. The mixture, as well as a blank, was incubated for 24 hours at 38°C when tests with iodine-potassium iodide solution showed the complete disappearance of starch. The digest was boiled and filtered and to the filtrate enough concentrated hydrochloric acid was added to make a concentration of 2 per cent, after which the solution was kept in boiling water for 2.5 hours. Then it was neutralized with sodium carbonate powder, cleared, de-leaded, made up to 250 c.c. and tested for reducing sugars as above.

Hemicelluloses. The solid residue after starch removal was treated the same way as the starch solution after digestion except it was necessary to filter before neutralizing the acid used in conversion of the hemicelluloses to dextrose.

Calculations. Allihn method and tables were used in all determinations of carbohydrates. Reducing sugars are expressed as dextrose while sucrose represents the difference in per cent between total sugars and reducing sugars multiplied by the factor 0.95. To obtain starch and hemicelluloses the dextrose figures were multiplied by the factors 0.93 and 0.90 respectively. Total carbohydrates represents the sum of all carbohydrates expressed as above.

Results. It was thought possible that the French Crab roots might have a higher percentage of sugars, particularly dextrose, therefore two varieties, Baldwin and Goodhue, were used in test with one-year French Crab before planting and one week after planting in the greenhouse. The following table gives the results.

TABLE 4.—*Reducing Sugars expressed as per cent of green weight before, and one week after, planting in the greenhouse, March 1928.*

Sample		Before	After
Baldwin		0.64	0.38
Fr. Crab	(Check on Baldwin)	0.68	0.04
Goodhue		0.68	0.07
Fr. Crab	(Check on Goodhue)	0.91	0.06

In the Baldwin test there is no significant difference before propagation but reducing sugars are much higher in the Baldwin after being planted one week. Yet the French Crab will root almost 100 per cent and the Baldwin, almost nil. In the Goodhue test, reducing sugars are higher in the French Crab at the beginning but there is no significant difference at the end of one week in the greenhouse. Apparently there is no accumulation of reducing sugars in the root pieces as a whole. They are probably used as rapidly as they are hydrolyzed from the stored foods. Since new

TABLE 5.—*Carbohydrate analysis of 1 and 2-year old roots from 11 year McIntosh seedling as compared with roots from 1 year French Crab seedlings before and after 16 days in the greenhouse. Jan. 9-25, 1929. Figures express per cent of green weight.*

Sample	Reducing sugars		Sucrose		Starch		Hemicelluloses		Total Carbohydrates	
	before	after	before	after	before	after	before	after	before	after
McI. Sdlg. A	.07	.009	1.58	.38	7.92	3.67	6.60	3.16	16.17	7.22
" " B	.10	.047	1.75	.94	6.91	3.82	5.26	3.57	14.02	8.38
1 yr. F.C. A	.015	.025	3.61	.62	6.17	5.21	7.63	3.93	17.42	9.78
" " B	.012	.004	3.69	.99	7.11	4.02	8.46	3.56	19.27	8.57
Average of Samples A and B of each lot										
McI. Sdlg.	.085	.028	1.67	.66	7.41	3.75	5.93	3.37	15.10	7.80
1 yr. F. C.	.014	.015	3.65	.80	6.64	4.67	8.05	3.75	18.35	9.18

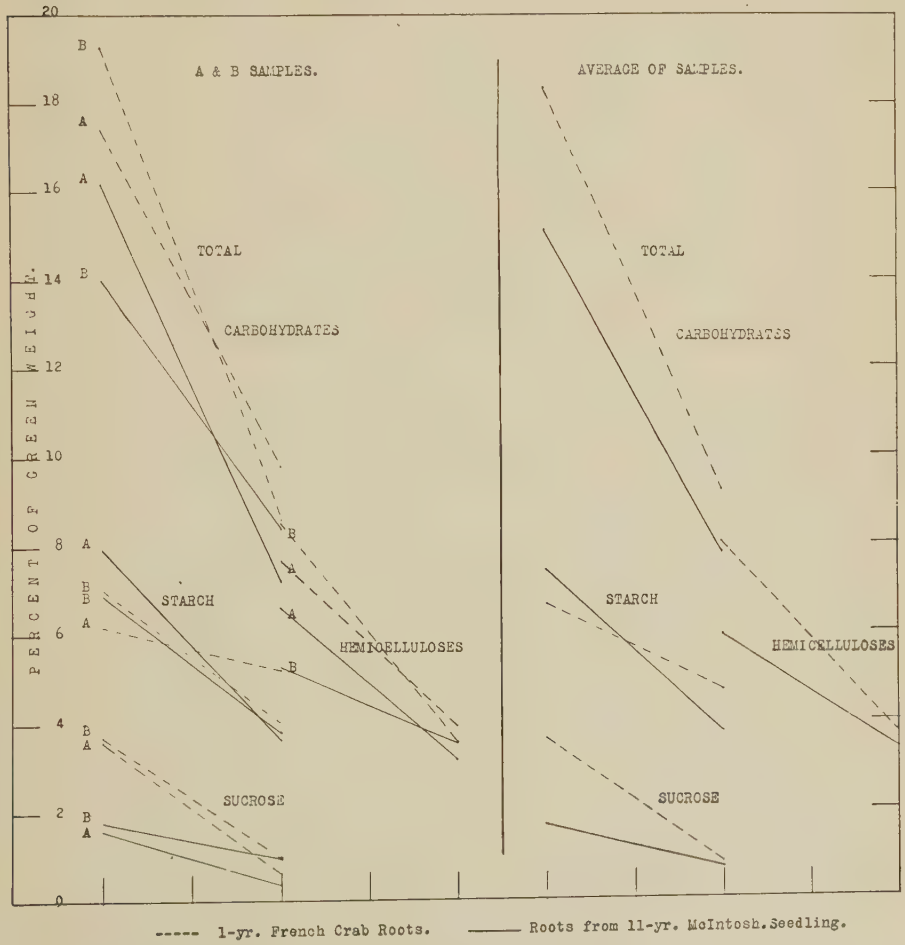

Figure 1. Carbohydrate content of 1 yr. Fr. Crab roots and roots from an 11 yr. McIntosh seedling before and after 16 days in sand-peat moss in the greenhouse, January 9-25, 1929. High point on each line represents original composition—low point, the resulting composition.

roots usually arise from the basal half inch of the root cuttings it would be interesting to know if there is any local accumulation of reducing sugars there.

On January 9, 1929, 20 gms. each of one-year roots from an eleven-year old McIntosh seedling tree and roots from some one-year French Crab seedlings were cut into 2½ inch pieces. The pieces were numbered and every second piece was immediately preserved for analysis. The other half of the root pieces were planted in the sand-peat moss mixture in the greenhouse. This test was performed in duplicate (A and B of table 5). After 16 days they were taken up, washed, and also preserved for analysis. The results are given in table 5 and also graphically illustrated in figure 1.

On March 27, 1929, the preceding experiment was repeated using roots from another McIntosh seedling of the same age and French Crab roots from the same lot. This time, however, the root pieces were left in the greenhouse bench fourteen days and not sixteen days as before. Results are given in table 6 and illustrated graphically in figure 2. Dextrose is not shown in figures 1 and 2 because of the small quantities found.

In tables 5 and 6 and figures 1 and 2 the roots may be examined as to carbohydrate content before and after propagation.

Reducing sugars. The percentage of reducing sugars has always decreased in the McIntosh seedling root pieces during propagation. Three times out of four reducing sugars have increased in the French Crab pieces during propagation. These results are contrary to those obtained in March, 1928 (table 4).

Sucrose. In January, (figure 1), sucrose was much higher in the French Crab pieces and it decreased more rapidly during propagation. In March sucrose was only slightly higher in the French Crab roots and it decreased at about the same rate as in the McIntosh seedling pieces.

Starch. In January the average starch content was highest in the McIntosh seedling pieces and decreased during propagation more rapidly in them. The reverse was the case in March.

Hemicelluloses. The hemicelluloses were higher in the French Crab at both times of the year and decreased more rapidly in them than in the McIntosh seedling pieces.

Total Carbohydrates. The total carbohydrates were higher in the French Crab pieces and decreased more rapidly in them during propagation.

French Crab roots give excellent results in propagation while root pieces from old seedling trees give a very small percentage of rooted plants which grow slowly. After about two weeks in the propagation bed new shoots of the French Crab began to appear above the surface (½-1 inch long) and roots began to appear at the basal end. Roots from an old seedling tree are just showing swellings at the upper end where buds are about to burst through the epidermis. Carbohydrates in general, except reducing sugars, were slightly higher in the French Crab root pieces and decreased more rapidly during propagation. No explanation can be advanced for the difference in comparative rates of starch disappearance at the two different times of the year (figures 1 and 2).

TABLE 6.—*Carbohydrate analyses of one and two year old roots from 11 year McIntosh seedling as compared with roots from 1 year French Crab seedlings before and after 14 days in the greenhouse. Mar. 27-Apr. 10, 1929. Figures express per cent of green weight.*

Sample	Reducing sugars		Sucrose		Starch		Hemicelluloses		Total Carbohydrates	
	before	after	before	after	before	after	before	after	before	after
McI. Sdlg. A	.56	.15	1.04	.55	6.70	3.31	3.56	2.68	11.86	6.69
" " B	.13	.08	1.33	.38	5.70	2.74	3.12	2.75	10.28	5.95
1 yr. F.C. A	.04	.08	1.60	.57	6.49	1.99	4.04	2.31	12.17	4.95
" " B	.03	.14	1.54	.75	7.58	3.00	4.65	2.55	13.80	6.44
Average of samples A and B of each lot										
McI. Sdlg.	.35	.12	1.19	.49	6.20	3.03	3.34	2.72	11.07	6.32
1 yr. F. C.	.04	.11	1.57	.66	7.04	2.50	4.35	2.43	12.99	5.70

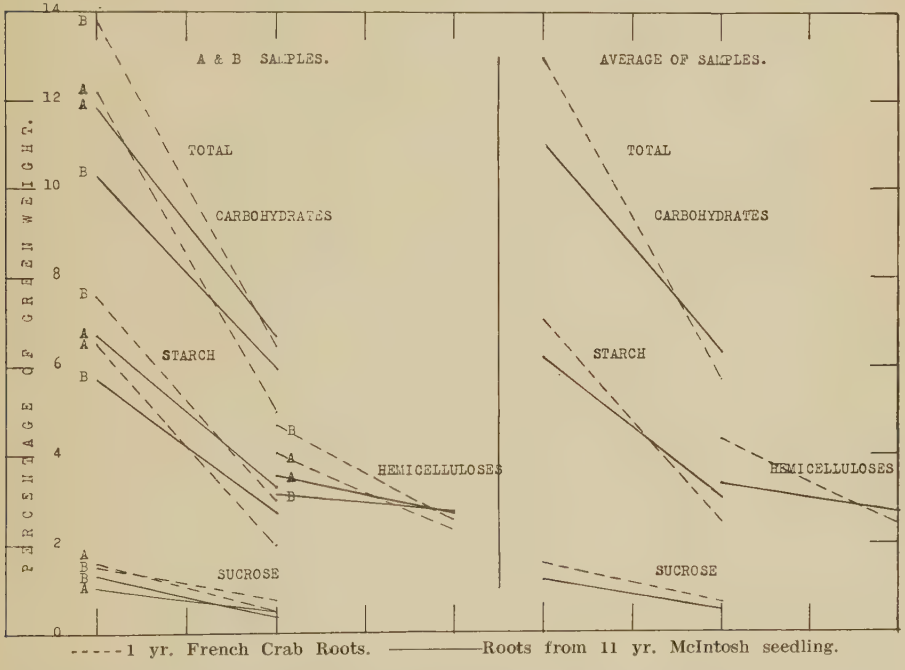

Figure 2. Carbohydrate content of 1 yr. Fr. Crab roots and roots from an 11 yr. McIntosh seedling before and after 14 days in sand-peat moss in the greenhouse, March 27-April 10, 1929. High point on each line represents original composition—low point, the resulting composition.

One would be inclined to expect from the foregoing carbohydrate analyses results that there would not be a great difference in propagation behaviour between the one year French Crab roots and the roots from an old seedling. Carbohydrate content and rate of decrease in propagation is not strikingly different. However, propagation results, as already stated, are very much different. Apparently the carbohydrates of the old seedling roots are used up in other ways than in the development of new root and shoot systems.

In passing, it is interesting to compare figures 1 and 2 with respect to carbohydrate content before propagation. Note that from January to March there has been a considerable decrease in total carbohydrates, mostly as a result of a decrease in hemicelluloses but partially reflecting a decrease in sucrose. Starch content has remained fairly constant. This seems to indicate that hemicelluloses are really reserve foods. This does not, however, prove that they have this rôle in roots attached to the trees, since figures for the two different dates (tables 5 and 6) are for roots of two different trees.

2. *Amylase*

It was suggested to the writer that low activity of amylase might account for the poor propagation results with roots from older trees. There seemed to be merit in this suggestion since when plants did develop from these roots they grew very slowly and the leaves were small and thin. The above figures on carbohydrate content and rate of disappearance were not obtained until after the investigations on amylase were well under way.

Methods—Measurement of the activity of amylase was tried first by timing the disappearance of starch from a weak solution of soluble starch using iodine as an indicator. The writer found it very difficult to determine the end point because of certain brownish colors given by iodine which were probably produced by oxidation products. Furthermore, when the material was dried and ground a good deal of starch was added along with the enzyme, possibly more starch than was in the substrate medium itself.

The errors in the gravimetric measurement of reducing sugars in the reaction mixture at various intervals were too great to allow of accurate measurement of the comparatively weak activity of amylase in apple roots. Therefore this method was also discarded.

The method finally adopted as standard was the viscometric method of Davison (*7*). The only difference was the substitution of boiled and centrifuged corn starch paste for the boiled and autoclaved soluble starch solution as substrate. In some cases samples were dried for twenty-four hours at 40°C, but because of the danger of weakening the enzyme drying at room temperature is more to be desired and this was the method used finally. In most cases 10 gm. samples of roots were used. It is possible to grind 10 gms. of bark with clean quartz sand and water to a satisfactory degree of fineness but it is not possible to do this with xylem samples. Therefore the latter must first be dried. A disadvantage in dry grinding is that some starch gets into the enzyme solution. Ostwald viscometers with 2 c.c. bulbs were used in this investigation. The substrate used was a 2 per cent corn starch paste boiled eight to twelve hours in a water bath and centrifuged for ten minutes at about 2700 r.p.m. This causes a separation into two layers, mostly beta amylose in the top and alpha amylose in the bottom layers (*16*). The top layer only is used as a substrate since it maintains its homogeneity and viscosity for at least two or three days. However it is safest to make fresh preparations of starch paste for each day's test. By concentrating and drying some of the amylose solution a standard powder will be available for making solutions at any time. It is best to make up the original starch paste in tap water since there are

no chlorides in distilled water and Sherman and Baker (*16*) have shown that chlorides are necessary to get good separation in centrifuging. The tap water used for this purpose contained 14 p.p.m. of chlorine.

Ten gm. samples of fresh roots were dried, ground in a mill, 20 c.c. of tap water added, stirred one minute, put in a piece of cotton, and pressed in a meat juice press with as much pressure as could be given by hand. The expressed juice was centrifuged for five minutes at about 2000 r.p.m. when the supernatant liquid was poured off. One half of it was boiled for thirty seconds to destroy the enzyme and this solution was used as a check. Each determination was run in duplicate. Two c.c. of the prepared starch paste was put into each viscometer and five minutes afterwards 2 c.c. of root extract was added to each. Mixing was done by drawing the reaction mixture up into the bulb and letting it run back three times. This proved better than blowing into the mixture since this method produced bubbles which later interfered with the readings. After ten minutes mixing the initial reading was taken and at the end of each succeeding five minutes up to 50 or 60 minutes another reading was taken.

In these experiments the digestion temperature was between 38 and 40°C. The viscometers were submerged in a glass battery jar itself about one-half submerged in a large water bath. There was about two-tenths of one degree difference in temperature between the water at the top and that at the bottom of the battery jar. By attention to the maintenance of a fairly constant air temperature the temperature in the battery jar could be maintained at a certain point plus or minus two-tenths of a degree.

Results. Table 7 and figure 3 illustrate the differences found between one year French Crab roots and one year roots from a ten year old McIntosh seedling with respect to the activity of amylase. It appears as if the enzyme was not entirely destroyed in the case of the French Crab check. Table 8 and figure 4 give a comparison between the bark and wood of one-year Baldwin roots and one-year French Crab seedling roots with respect to the activity of amylase. (Bark refers to all parts outside of the cambium). The results given below are representative of many more tests on amylase.

TABLE 7.—*Activity of amylase in extracts from one-year French Crab roots and roots from a 10-year old McIntosh seedling. Twenty gms. of material, bark and wood combined, dried 24 hrs. at 40° C., ground to a fine powder and added 40 c.c. of water. Centrifuged 3% corn starch paste was used as a substrate. Figures express per cent of original viscosity.*

Time (Minutes)	McI. Sdlg.	McI. Sdlg. Check	Fr. Crab	Fr. Crab Check
0	100	100	100	100
15	100	100.2	98.5	100
30	100	100.2	97.7	99.8
45	99.6	100.2	96.9	99.6
60	99.6	100	96.5	99.6
75	99.8	100	95.7	99.6
90	99.8	100	95.2	99.8
105	99.6	100	94.7	99.6

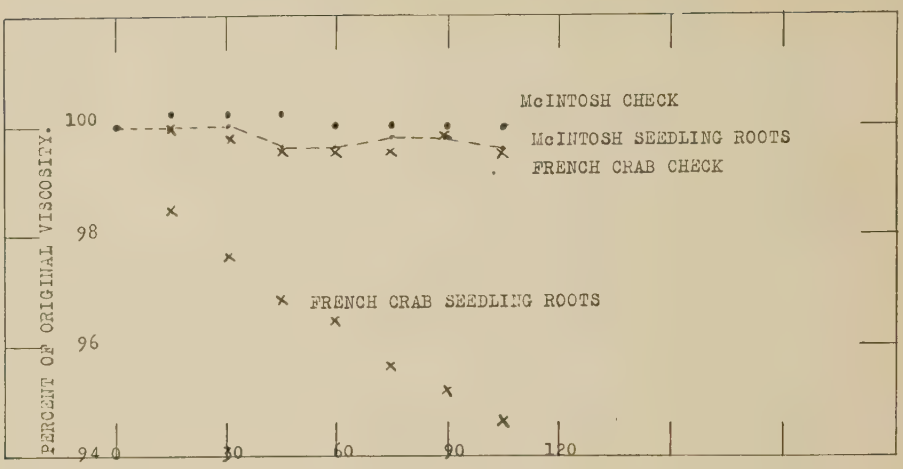

Figure 3. Activity of amylase in 10 yr. McIntosh seedling roots and in 1 yr. Fr. Crab seedling roots as measured by decrease in viscosity of starch paste, June 5, 1928.

All tests on amylase have shown that the activity of amylase is considerably less in variety roots and roots from old seedling trees than it is in one-year old seedling roots. It has not been determined whether the difference in activity is due to a difference in quantity of enzyme, quantity of activating salts or reaction of the cell sap. On February 4, 1929, the sap was squeezed out of one year French Crab roots and out of one year roots from an eleven year McIntosh seedling. The former gave a pH of 5.7 and the latter, a little over 5.8. It seems that this difference would not account for the differences found in the activity of amylase.

TABLE 8.—*Activity of amylase in extracts from one-year French Crab roots and one-year Baldwin roots. Bark samples, 10 gms. each, were ground wet with sand. Wood samples were dried for 24 hrs. at 20° C. and ground. Fifteen and twenty c.c. of water respectively were added. Centrifuged 2% corn starch was used as a substrate. Figures express per cent of original viscosity.*

Time in Minutes	Bark				Wood			
	Fr. Crab	F. C. Check	Baldwin	Baldwin Check	Fr. Crab	F. C. Check	Baldwin	Baldwin Check
0	100	100	100	100	100	100	100	100
5	98.9	100	98.8	100.3	96.9	100	98.4	99.7
10	97.6	100.3	98.1	101.3	95.1	100.4	96.6	99.8
15	97.1	100.0	97.6	100.8	93.2	100.4	96.2	100.1
20	96.5	100.3	97.2	101.1	92.2	99.8	94.7	100.0
25	96.2	100.9	96.7	101.3	91.2	100.0	94.0	99.9
30	96.1	100.6	96.4	101.3	90.3	100.1	93.5	100.2
35	95.1	100.9	96.3	101.6	89.1	100.0	93.0	100.1
40	95.1	100.9	95.8	101.3	88.2	99.7	92.6	100.0
45	95.1	100.9	96.0	100.5	87.8	100.0	91.5	100.1
50	95.2	100.9	95.1	101.3	87.7	100.0	91.1	100.1

NOTE.—Results on bark cannot be compared with those on wood since the conditions were different. Same applies to figure 4.

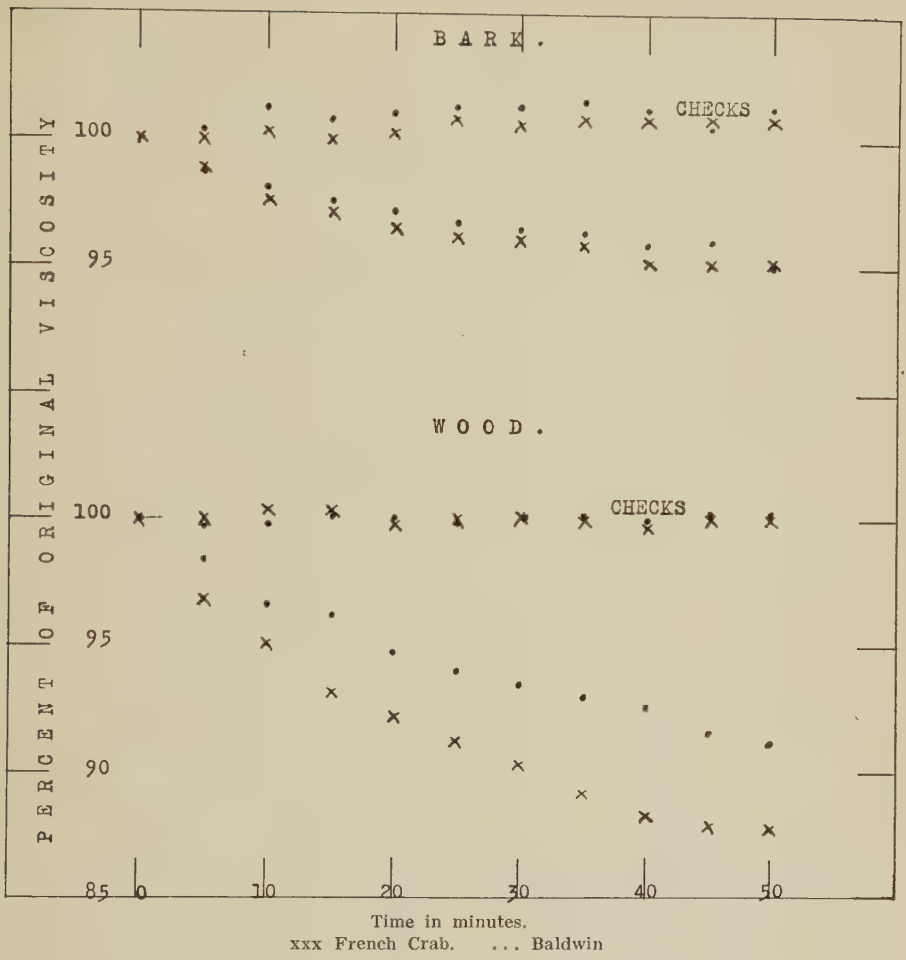

Figure 4. Activity of amylase in bark and wood of 1 yr. Baldwin scion roots and 1 yr. Fr. Crab seedling roots as measured by decrease in viscosity of starch paste, April 9, 1929.

In the Baldwin roots (figure 4) there is little reduction in activity in the bark but the wood of same clearly lacks in activity of amylase in comparison with one-year French Crab roots. In figure 3 it may be seen that the activity of amylase is almost nil in the case of the roots from an old seedling tree.

The differences in activity of amylase just mentioned can scarcely be reconciled with the results on starch disappearance in the propagation bed. In January (figure 1) starch actually disappeared more rapidly from the old seedling roots than from the French Crab root pieces. This is contrary to what one would expect considering the greater activity of amylase in the latter roots. Apparently other factors besides amylase determine the rate of starch hydrolysis in the root pieces. On the other hand, the April results on starch disappearance (figure 2) show some correlation with activity of amylase.

Treatments designed to increase the activity of amylase or to increase the end products of its catalysis (sugars) in variety and old seedling roots.

(1) Addition of amylase—Soaking variety and old seedling roots in taka-diastase solutions or drawing the solution through the pieces by means of suction did not give increased rooting.

(2) Addition of extract of one-year French Crab roots like the above gave negative results.

(3) Treatment with ethylene gas, 1-400, for eight days on one test gave no stimulation to the root pieces either in roots or tops.

(4) Addition of chlorides as activators. Doby and Hibbard (*8*) and others have shown that chlorides activate amylase. Soaking in .02m.KCl and NaCl solutions for twenty-four hours, or drawing the same through the vessels by suction did not give increased rooting.

(5) Growing root pieces in chloride solutions made up in distilled water and of the strengths given above gave some increase in rooting over checks in distilled water. Pieces were placed upright in 250 c.c. beakers, containing about one inch of solution which was changed every day. However, when the chloride solutions were made up in tap water and the latter used as a check the pieces in tap water alone rooted often times as well as those containing KCl or NaCl. As already mentioned this tap water contained about 14 p.p.m. of chlorides.

Usually, however, it was not possible to induce more than one-quarter of the pieces to produce new roots in tap water or any chloride solution. Most new roots were produced two to three weeks after starting. After that time slimy moulds formed at the base of the pieces and it was thought these might produce toxins inhibiting further rooting. It appeared many times that new roots were about ready to emerge but never did actually appear. However, by treating the root pieces with Semesan, 1-400, for five minutes before propagation and then using sterile tap water in making up the salt solutions, results were no more satisfactory as regards rooting, though no slimy moulds could be seen with the eye.

Apparently chlorides are actually taken in to the root pieces; 41.7 gms., 20 root pieces, of an old seedling, absorbed from a .02m.KCl solution in 65 hours 10.5 mgms. of chlorine. These pieces were standing upright about one-half submerged in solution in a beaker in the greenhouse. It is highly probable that the chlorides were taken into the vessels with the water though this was not determined.

(6) Addition of sugars. Ten gm. samples of 10 yr. Duchess seedling roots were treated as follows: (1) Check—not soaked (2) soaked 24 hours in 3 per cent glucose (3) soaked 24 hours in 6 per cent sucrose. Each treatment was given in duplicate. Table 9 gives the results on sugar intake, figures expressing per cent of green weight.

Considering the normal variability there is no indication that sugars were absorbed by the root pieces as a result of twenty-four hours soaking in sugar solutions. There is a slight possibility that sugars were taken in

and immediately changed to an insoluble carbohydrate. However, since root pieces are not lacking in reserve carbohydrates this possible occurrence is not of special importance.

TABLE 9.—*Results of soaking root pieces in sugar solutions.*

Sample	Reducing Sugars	Sucrose	Total Sugars
Check A—not soaked	.91	1.73	2.74
" B— " "	.60	1.46	2.13
Glucose soaked A	.81	1.26	2.14
" " B	.93	1.28	2.28
Sucrose " A	.98	1.64	2.70
" " B	1.06	1.52	2.66

In another experiment a single root from an old McIntosh seedling tree was cut up into pieces, the odd numbered pieces preserved at once for analysis and even numbered pieces soaked for one week in 5 per cent glucose with daily changes of solution, after which they were washed and preserved for analysis. The check had 0.86 per cent of reducing sugars and the treated lot, 0.84 per cent of reducing sugars, clearly no significant increase or decrease therein. In both the above experiments the treated root pieces were completely submerged in the solution.

In a third experiment about 40 gms. of roots from an old seedling were placed upright in each of two beakers. There were about 20 pieces in each. Both lots were treated for five minutes with Semesan, 1-400, after which to one was added 50 c.c. of sterile 2 per cent glucose and to the other 50 c.c. of sterile 5 per cent sucrose. After 48 hours the solutions were tested for sugars and compared with the original solutions. It was found that 206 mgms. of glucose and 387.6 mgms. of sucrose disappeared from their respective solutions. The solutions seemed to be still sterile after 48 hours. It is quite possible that the sugars entered the vessels with the water and if they did there is still a question about their passing from the vessels to adjacent cells.

Why the difference in absorption of sugars between submerged root pieces and pieces standing upright in about an inch of solution and exposed to the air? This is a possible explanation. As water is transpired from the top cut surface sugar solution rises in the vessels by capillary action, the water column remaining unbroken due to the force of cohesion. In submerged cuttings there is no transpiration and therefore no force is exerted to cause the entry of sugar solutions into the vessels.

Many attempts were made to induce rooting in sugar solutions. One of the early successes was with a small lot of small Helm roots. Sugar solutions were changed every day in this as in all other sugar "feeding" experiments. After two weeks treatment with 5 per cent sucrose, 2 per cent glucose was given for five weeks at the end of which period five out of seven had healthy roots but practically no new tops. A check in tap water gave no rooted individuals (see plate 8).

Plate 8.

Upper row—Helm root pieces grown in sugar solutions.
Lower row—Helm root pieces grown in tap water. Five out of seven of the former have rooted.

Succeeding trials along this line met with failure because of the failure of the sugar solutions to remain sterile. Moulds were much favored in the sugar solutions. Finally it was determined that such difficulties could be largely overcome by treating the root pieces with Semesan, 1-400, for five minutes. Furthermore, it was found desirable to make up the sugar solutions in tap water.

The best result ever obtained in a sugar solution was when treating 39 root pieces from an old McIntosh seedling with 2 per cent glucose. On January 30, 1929, the experiment was started, daily changes of 2 per cent glucose being given until February 20, by which time 15 had rooted. As no more roots were emerging the remainder were planted in a sand-peat moss mixture in a glass-covered bench in the greenhouse. On March 4, 10 more pieces had rooted, making 25 in all out of the 39 or 64 per cent. A later test along this same line has not given as favorable results. From results obtained so far with sugar solutions, especially glucose solutions, it appears desirable to continue work with them. By controlling conditions properly and growing for two or three weeks in glucose solutions and then transferring to a solid medium it may be possible to get a high percentage of rooted plants.

3. *Catalase*

Method—One-half a gram of bark was put in a mortar, .5 gms. of $CaCO_3$, 2 c.c. of distilled water and a pinch of sand added. Mixture was ground three minutes, 8 c.c. of water added, and all poured into a test tube. Immediately after vigorous shaking 1 c.c. samples were taken. 5 c.c. of 3 per cent hydrogen peroxide was used in the reaction and 1 c.c.

of water was added to the 1 c.c. of catalase solution in the reaction bottle. The apparatus and procedure was the same as that used by Appleman (*2*), except that the experiment was carried on at air temperature. On each sample the recorded reading is the average of two closely agreeing readings. During comparative tests the air temperature was kept constant.

No variety root pieces were tested for catalase but at two different times catalase activity in one-year French Crab roots proved to be higher than in roots from an eleven year old McIntosh seedling.

TABLE 10.—*Catalase activity in bark of roots taken Feb. 11, 1929.*

Kind of root	Root No.	Sample	Average Reading in c.c. of oxygen given off
1 yr. Fr. Crab	1	A	16.0
"		B	16.3
"	2	A	14.2
"	3	A	18.2
McIntosh Sdlg.	1	A	6.5
"		B	8.0
"	2	A	10.1
"	3	A	15.1

McIntosh seedling Root No. 3 was a small one, about ⅛" in diameter. The other roots were larger. This small one is the only one which comes up to the level of the others in catalase activity.

TABLE 11.—*Catalase activity in bark of roots taken Mar. 30, 1929.*

Kind of root	Root No.	Average reading in c.c. of oxygen given off
1 year Fr. Crab	1	22.2
"	2	18.6
McIntosh Sdlg.	1	9.6
"	2	14.7

In the above tests catalase activity was greater in the French Crab roots than in roots of the same age from an old McIntosh seedling tree.

Heinicke (*12*) states that there is a high correlation between nitrogen content of the tissue and its ability to destroy hydrogen peroxide and that an accumulation of carbohydrates tends to depress catalase activity. It has been already shown that carbohydrates are usually slightly higher in the French Crab roots than in roots from an old seedling tree. Therefore, taking Heinicke's conclusions into consideration it seems reasonable to suppose that the roots from an old seedling have a lower nitrogen content than the French Crab roots. The latter grow well from root cuttings and the former poorly. No comparative tests on nitrogen content have been made.

4. *Respiration*

Method—The method of measuring respiration was essentially that used by Bailey (*4*) in the early stages of his studies on the respiration of shelled corn. Twenty-five c.c. of nearly saturated $Ba(OH)_2$ solution was

used in the absorption of the CO_2 gas, the latter being bubbled through slowly for twenty minutes when tests showed practically all the gas had been withdrawn from the 500 c.c. respiration chamber. The CO_2 gas was allowed to accumulate for from six to twelve hours only. In titrating the $Ba(OH)_2$ solutions .54N HCl was used. The quantity of root pieces used was 75 gms., French Crab roots and McIntosh seedling being compared again. In one test the respiration of each was measured. Then the same root pieces were planted in sand-peat moss mixture in the greenhouse bench where they were left for one week when the respiration was again measured. The results given below express in c.c. of .54N HCl the amount of $Ba(OH)_2$ solution converted by the CO_2 gas to $BaCO_3$.

	French Crab	McIntosh Sdlg.
1st period—6.5 hrs.—	2.0	2.0
2nd " —12 " —	7.2	7.3

Since these roots were respiring in the laboratory where the temperature varied the periods cannot be compared one with the other. Only a comparison between the two kinds of roots is justified, showing no significant differences in rate of respiration. After one week in the propagation bed the results were:

	French Crab	McIntosh Sdlg.
Period of 6 hrs.	4.9	3.8

At this time the French Crab is respiring more rapidly than the root pieces from the old McIntosh seedling tree.

Roots of another McIntosh seedling of the same age and of one-year French Crab had been in the respiration chambers for three days before a reading was obtained. The chambers had, however, been opened several times during the interval. Results were then obtained as follows:

	French Crab	McIntosh Sdlg.
Period of 8 hrs.	5.9	9.7

In this case the McIntosh seedling root pieces were respiring much faster. It is worthy of note that the lenticels of the McIntosh seedling pieces were much more swollen than those of the French Crab pieces. Immediately after these pieces were taken out of the respiration chamber they were tested for catalase with the following results:

Diameter of root piece	French Crab	McIntosh Sdlg.
Small	17.2	11.9
Medium	23.7	13.7
Large	18.7	10.2

It is clear from the above results that there was no positive correlation between respiration and catalase activity.

5. *Anatomy of Apple Roots*

In the early stages of the investigation it was thought that the reason for the failure of variety root pieces lay in some fault in anatomical structure. In cutting roots with knife or pruners but especially in preparing roots for grafting the wood of the variety piece was noticeably harder to cut than the wood of the one-year French Crab seedling roots. Possibly

a partial explanation of this difference lies in the greater number of wood fibres occurring in the xylem and pericyclic fibres in the phloem of the variety root piece. The pericyclic fibres of the French Crab root pieces were either lacking or very scattered. In the variety root pieces they occurred in large detached masses throughout the phloem. No other differences in anatomy were consistently found. When it was considered that a few of the variety root pieces would root, but especially after it was discovered that a French Crab "nurse" top would induce a large percentage of the variety pieces to root, anatomical investigations were largely dropped in favor of the nutritional phases.

Vascular Blocking—Soon after planting apple root cuttings the vessels become more or less blocked with a gummy substance. It occurs not only at the cut ends as wound gum (*18*) but extends the whole length of the cutting. Even in cuttings four inches long gum occurred in the vessels midway the length of the cutting. Ordinarily, however, it forms first near the ends.

This substance stains yellow with iodine, pink with Sudan III and red with phloroglucin and concentrated HCl. It is insoluble in chloroform, ether and 15 per cent NaOH.

The gum forms as soon as one week after planting but does not form in roots attached to the parent tree under the same conditions. Neither does it normally occur in roots until they are cut into pieces. It forms sparingly in the one-year French Crab seedling roots and formed to only a limited extent in the variety roots obtained from California. In all Eastern variety roots and roots off old seedling trees it formed abundantly and in a week or two water could not be forced through the vessels even under a pressure of a ten foot head of water. Before beginning propagation water could readily be forced through the root pieces with this pressure. The gum forms also in cuttings of apple shoots. However, gum formation in the vessels does not inhibit rooting since in the root piece grafts where a "nurse" top of French Crab was used the variety roots as stock showed abundant gum in the vessels but yet a large portion of them had rooted well. LeClerg and Durrell (*13*) found a similar plugging in the vascular system of diseased alfalfa plants. It is not tyloses since it often forms a solid block over the cross section of the vessel.

The writer has found no treatment which will prevent gum from forming in the tracheae. Keeping the ends moist with moist cotton covered with a water proof material and waxing the whole piece or just the ends of it has a tendency to retard but not prevent gum formation. It will form even in pieces kept continuously upright in an inch of water regardless of whether or not the exposed end is waxed, though in this case there is marked retardation in the formation of gum. High temperatures hasten the appearance of gum.

If the developing bud and root initials are dependent for their water supply on that transmitted through the tracheae then the gum in the vessels is a distinct drawback. If, on the other hand, water is passed from cell to cell, gum in the vessels may not be a disadvantage. Because

the open vessels offer an easy entrance for organisms, the blocking with gum at the ends may be distinctly advantageous.

6. *Water Relations*

On October 15, 1928, 10 gms. each of one year Hubbardston seedling roots and roots from a ten year old McIntosh seedling tree were cut into slices about 2 mm. in thickness, and dried at 40°C. Results on relative rates of drying are shown in table 12.

TABLE 12.—*Weight of roots at intervals on drying at 40° C.*

Time in hours	10 year seedling root pieces	1 year seedling root pieces
0	10	10
1	6.9	7.05
2	5.7	5.0
3	5.4	4.15
4¼	5.4	4.0
5¼	5.4	3.95
7¼	5.4	3.95

There is certainly a higher water content in the roots from the one year old seedling and the last portion of the water is lost slowly in the case of these roots, indicating a greater water-retaining power against drying. In the roots from a ten year old tree based on green weight the percentage of water is 46 and in the roots from a one year old seedling, 60.5 per cent.

Roots which gave poor tops or none at all in solid media gave good growth of tops when grown in solutions of sugars, chlorides, or oxidizing agents, as well as in tap or distilled water alone for two or three weeks time (see plate 9). This did not necessarily mean better rooting but at least it proved that the top growth could be much increased by improving facilities for water intake and suggests the desirability of further work along this line.

7. *Chemical Stimulation*

The chloride solutions used have already been dealt with under the subject of "Amylase". One-half a part per million of boron, as boric acid, in distilled water was used as a medium for older seedling roots but it failed to give any increase in rooting over a distilled water check both used as continuous treatments. Winkler's success (*19*) with oxidizing agents on grape cuttings led the writer to try .001m. $MnSO_4$ in distilled water as a stimulant. The basal ends of the root pieces were kept in this solution for 42 hours after which the cuttings were given daily changes of tap water. Rooting was no better than a check kept continuously in tap water. In another experiment some roots were given hydrogen peroxide treatments as follows: (1) 3 per cent H_2O_2 for 15 minutes (2) 0.3 per cent H_2O_2 for 48 hours (3) grown in 0.3 per cent H_2O_2. These solutions were applied only to the basal ends. The first two gave negative results while the last treatment stimulated top growth, though no roots formed. Possibly the stimulus to the top was due to the antiseptic effect of hydrogen peroxide in the solution.

Plate 9.

Root pieces from an 11-year McIntosh Seedling.
Upper row—Grown for 21 days in tap water and then for 18 days in sand.
Lower row—Grown continuously in sand for 39 days.

Discussion

In the later stages of the investigation on water culture treatments a glass covered frame was placed over the propagation bench. This gave an atmosphere almost saturated with water vapor around the cuttings. Larger leaves and more vigorous growth was secured. Bottom heat in moderation seemed to be an advantage in rooting though no comparative tests were employed. Much difficulty was experienced in damping off in the young shoots and rot in the bark of the cuttings. Watering must be done as infrequently as possible and only in the mornings of bright days. Furthermore the frame top must not be tight but allowance must be made for some ventilation. Adequate ventilation together with a saturated atmosphere would be ideal conditions but are not easy to attain. Soaking the cuttings for five minutes in Semesan, 1-400, does not prevent bark rot. Cuttings in pure sand seem to show less of the bark rot than those in peat moss or peat moss-sand mixtures. It is not known whether the bark rot is a specific disease causing death or whether death of the cutting occurs and the rot follows. The rot begins at the cut ends and spreads to the middle of the cutting. Sometimes there is little trouble from this cause and at other times it is the factor determining failure. Future efforts must be directed to its control and to the control of the damping off fungus.

In the absence of disease variety root cuttings and roots of old seedling trees produce one or two shoots each which grow slowly. When they produce roots the latter are weak. Starch disappears from the root

piece very slowly. There may still be some of the original stored starch present after four or five months in the propagation bed. In the few stem cuttings grown in conjunction with root cuttings starch disappearance was markedly more rapid in the former. French Crab root pieces on the other hand root well even in the dark (see plate 10), also when the leaves are removed as they appear, and often roots will be found before the tops have appeared above the surface of the bed. If we could grow variety roots and roots of older seedlings as rapidly as apple roots grow from seed we might have the former approaching the latter in structure and physiological state. Then we would probably have better success in propagating the roots with which we now have difficulty. The roots obtained from Shafter, California, were apparently more nearly in the state of the French Crab roots and better success was obtained with them. In the case of own-rooted variety plants the roots grow so slowly that it is two or three years before there are roots sufficiently large for propagation purposes. At this time the roots have passed into the condition in which it is difficult to induce them to make vigorous new plants from root cuttings. French Crab seedlings, two and more years of age, are also difficult to propagate from root cuttings. Growing the root pieces in water or in solutions of sugar seems to give the most promise in the invigoration of these root cuttings.

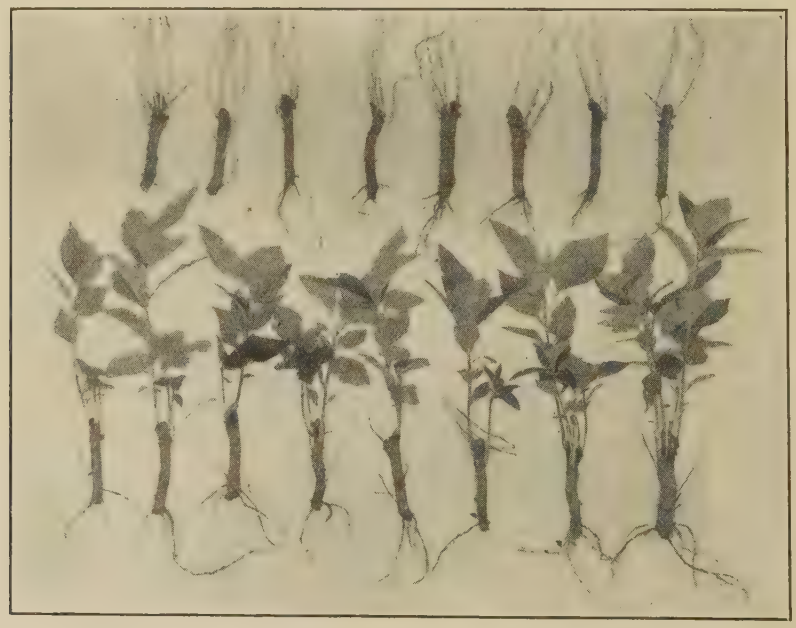

Plate 10.

One year French Crab seedling root pieces.

Upper row—Grown in the dark.

Lower row—Grown in the light.

Note that all the shaded pieces have rooted though not as abundantly as the pieces grown in the presence of light.

Summary

1. Apple roots can be divided into two classes with respect to the ease with which they can be propagated from root cuttings. Class 1. Roots of plants grown one season from seed, commonly known as one-year seedlings. Class 2. Scion roots of any age and roots of seedlings more than one year old. Class 1 produces new shoots and roots and grows rapidly. Class 2 produces a high percentage of plants with shoots but very few with new roots and those that finally survive grow slowly.

2. Grafting variety stem scions on root pieces of Class 2 does not induce rooting of these root pieces but grafting root pieces of Class 1 as a "nurse" top on root pieces of Class 2 induces better rooting of the latter.

3. Roots of Class 1 usually have a slightly higher carbohydrate content.

4. Roots of Class 1 show higher activity of the enzymes Amylase and Catalase.

5. There are no consistent differences in rate of respiration between the root pieces of Classes 1 and 2.

6. Gum appears in the vessels of all root pieces as soon as one week after planting and shortly becomes an effective barrier to water passage in the vessels. It appears most rapidly and in most abundance in the root pieces of Class 2.

7. The only consistent difference in anatomical structure between the roots of these two classes is the greater abundance of wood and pericyclic fibres in the roots of Class 2.

8. Two or three weeks growth in water or sugar solutions and after that transference to a solid medium gives the most promise in the rooting and invigoration of the root pieces of Class 2.

Acknowledgments

The writer wishes to gratefully acknowledge the co-operation of Mr. G. E. Yerkes and Mr. L. B. Scott, both of the United States Department of Agriculture, in supplying material. To the staff of the Department of Horticulture at the University of Maryland and especially to Dr. E. C. Auchter and Dr. F. E. Gardner the writer is indebted for much assistance on this problem. Thanks are due also to Director E. F. Palmer of the Ontario Horticultural Experiment Station for his co-operation in the later stages of this investigation.

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WHEAT FARMING IN SOVIET RUSSIA AND ITS RELATION TO EUROPEAN AND AMERICAN WHEAT PROBLEMS [1]

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Introduction

What is the Soviet Russian farm programme in relation to the five year plan? What are the potentialities of commercial, industrial, and agricultural expansion in this land symbolized by the emblem of the sickle and the hammer? What influence will these developments have upon European and American agricultural problems? The interest in and importance of these questions are not unique to the group gathered here this evening but are associated equally with every phase of our agricultural and economic readjustment.

The huge experiment in communistic mechanization and industrialization of agriculture, industry and exchange, of life and social organization, may fall short of accomplishing the results outlined in the five year plan but it is evident that their chances for success are much greater through large scale grain farming than in any other line. The climate, the soil, as well as the peasant population over the greater portion of Soviet Russia are adapted to grain production. Literally, bread has been the staff of life to these people for centuries.

The problem of agricultural readjustment we are facing today is not new. History repeats itself. For example from 1883 to 1887, competition of Indian wheat on the European market was a topic of discussion in commercial and agricultural circles. Such statements as the following were made: "India can produce an average quality of wheat at as low cost as the most favorable localities in the United States", "India possesses facilities for increasing the supply of wheat to an almost unlimited extent due to the *great elasticity* of the home consumption and the *vast amount* of *land available*", "That in quality, facilities for handling, safety against damage and stability of money exchange, American wheat has such advantages that there need be no serious apprehension on account of Indian competition at *legitimate prices*", and finally, conclusions such as: "The American farmer will have to prepare himself to reduce the cost of production to the lowest minimum and be content with small profits." Nothing was said, however, about decreasing acreage, farming as a business, coöperative marketing, grain pools, and so on; these are modern phrases. But essentially the problem today is not different.

The key questions regarding Soviet Russia today are essentially:

1. The vast amount of land adaptable to cereals.
2. The great elasticity of home consumption.
3. Competition at economically legitimate prices.

The American problems may be defined as;

1. A cheaper production of quality wheat.

[1] Abstract of talk delivered before the joint meeting of the Canadian Society of Technical Agriculturists and the Canadian Phytopathological Society, Guelph, Canada, June 22, 1931.

[2] Professor of Plant Pathology.

2. Diversified farming and reducing wheat acreage at least during this period of world surplus of wheat.

3. Greater per capita consumption of wheat with lower prices.

The Russian Five Year Plan

The operation of the five year plan has been directed largely towards the subjection of individualism to the massed action of communism in the industrialization of the nation. It is not a direct attack against the principles of capitalism except as it pertains to individual citizens and their advancement. The state is using the principles of capitalistic administration in the operation of the government trusts through which every phase of the government production, distribution and exchange is conducted.

The so-called five year plan is an attempt to make Soviet Russia economically independent in the five year period. They are attempting the completion of an industrial and agricultural programme in five years which will enable them to carry on their development even though cut off from the rest of the world. No sacrifice in individualism is too great if it is made to advance this programme. The consideration of economic principles must not inhibit this development. The building and developing is going on in great haste and with what is obviously a tremendous waste of resources. The foreign purchases of basic machinery and technical advice are being met largely by the export of natural resources and agricultural products at what are obviously large sacrifices and wastes of both.

The Agricultural Programme

The development of the agricultural programme has been along farm crop lines. Sufficient livestock is not yet available even for adequate internal needs and, furthermore, the people are more familiar with the production of grains and fruits than with the care and handling of livestock and meat and dairy products. Likewise, the climate and soil of the central area are better adapted to grain production. The agricultural methods in most of the country are still very primitive and the standards of living very low. Whether on the peasant farm, the collective farm or the trust farm, the farmer has no modern conveniences as found on the American farm. The mass farm production must start, therefore, with the production of relatively few crops on a single crop culture basis and advance toward diversified farming as the farming population advances in intelligence.

The peasant is principally a grain farmer raising sufficient rye, wheat of Soviet Russia. In the mountainous regions, in the timbered areas, and on the areas less adapted to power farming the peasant occupies most of the land under cultivation. These peasants live in the villages situated in sheltered places where water is available and go out each morning over dirt roads usually no more than trails to cultivate their small parcels or strips of land situated at various places within a radius of three or four miles of the village and return home again in the evening.

The peasant is principally a grain farmer raising sufficient rye, wheat and barley to supply his demands and pay the government tax or rent for the use of the land. In the larger portion of rural Russia, the peasant is still self sufficient, depending upon his small farm and home unit to

supply the necessary food and clothing. In many of the local areas tea, sugar, salt and oil for cooking are now available through the government coöperative stores. In the more advanced areas, the government is furnishing ploughs, pedigree seed and the use of the small threshing machine to peasant and collective farmers to speed up crop production. In general, the lowest cost of grain production is in the areas where the government, through the tractor centres, has supplied the essential farm machinery to supplement cheap and abundant farm labor in connection with grain production on peasant and collective farm alike.

The collective farm is giving the peasant little improvement in his standard of living but is speeding up his production by massed coöoperative effort. The collective farm (*kolkhoz*) is made up of the contiguous holdings of peasants combined into a communistic farm unit with an industrial worker, member of the government party, as leader. Usually an area of 60-200 acres generally adaptable to power farming is selected. The ten to fifteen peasant families occupying this area combine into a larger social unit with common rights, common kitchen and club room. If the area is some distance from the village new buildings are constructed on the grounds, if it is surrounding the village, the village is modified to meet the demands of this new social unit. The government furnishes funds for buildings, machinery and seed and the group becomes a new social organization, a potential farm producing unit. Wooden barracks to house the people are constructed on this tract of land, a common kitchen equipped with board tables and benches is built and a club room or social hall, frequently part of the mess hall, is decorated with Soviet banners of red cloth, cheap posters in bright colours and cheap print pictures of the communist leaders. This room is supplied with simple books on principles of economics and government, methods of farming, and with newspapers; it has become the new social and educational centre of this communistic group, and yet this cannot be called a home. The home as we know it is gone; it is not efficient, the Soviets say. These groups of ten or more families have given up the family life and have joined together as a massed unit to produce agricultural products more economically to further the programme.

The actual efficiency of production usually depends upon the organizing ability and leadership of the party member in charge of the coöperative group. Each collective unit is composed of 30 to 60 adult men and women workers. With the centralized living and eating and the use of farm machinery to replace the hand labour, there is immediately a labour surplus of 50 to 60 per cent. The problem at present is what to do with the excess labour. In some instances they can be hired out to nearby government trust farms or experimental farms, some can be put on government road work or some of them can be shipped to nearby industrial centres to work in new factories, but in general they are held on the farms working on a very inefficient basis and having to be fed and clothed from the products of the collective farm. The collective farm is playing an important part in developing communism and in speeding up production in the Ukrainia and the North Caucasus where they occupy 20 to 30 per cent of the farm area. Even this development has not met the government demand for increased production, and due to the problems

of surplus labor, inefficiency of leadership of the party member in charge, high operative costs and other problems, emphasis is now being directed toward a more centralized, industrial farm unit, the trust farm.

The trust farm is designed as an industrial farm unit. Organized on the basis of the government industrial trusts, it is in operation on large scale farming in grain production, as for example the "Gigant" (Giant) and the "Verblud" (Camel), also on a lesser scale in grain and cotton growing and fruit culture, and this summer is being introduced on a smaller scale as perhaps the most efficient method of bulk agricultural production. Contiguous peasant tracts adaptable to power farming are combined into these small trust farms. The former peasant tiller of the land may work on the new farm as an industrial worker for wages under the trained agronomist manager or seek land elsewhere. The government owns the land, the peasant is allowed to farm it as an individual by paying taxes for the use of the land until the government can use it more efficiently in some other way. Centralized managerial responsibility and machinery will enable them to speed up production, and therefore, the individual peasant must give way as the landlord did earlier for the development of the programme.

The government subsidizes the building and equipping programme of this unit and finances its operation by loaning specified sums to the trust. Barrack-like bunk houses, a coöperative kitchen and social hall are constructed. Modern farm machinery is supplied or loaned from the nearby "tractor centre". Pedigree seed of the standard, adapted varieties of the crop to be grown are furnished from the nearest government seed trust farm. The necesary labor to operate the farm is hired on the same basis as in the industrial centres and this new industrial farm unit is brought into the programme for speeding up production.

Here again, the efficiency and economy of production on these farm units depends upon the managerial ability of the agronomist in charge. It is centralized responsibility, however, and where sufficient labor is available this type of farm is operating successfully. Increasing crop production is the important factor at present; the cost of production becomes entirely secondary in the present economics of the country. This is due to two principal conditions; first, the government furnishes land and equipment, and secondly, the relatively high prices paid in rubles for the crop produced. Both of these conditions are made possible by the fact that the government owns all land and that the government internal purchases are made with paper rubles which cost the government nothing except the cost of printing.

Production Has Been Increased

The reorganization and industrialization of the peasant and small collective farm and the development of the large government trust farms in the semi-arid regions has increased the acreage and yield of grain. This increase in acreage has been followed by the forced use of standard varieties of recognized quality which has simplified the grain collection and further increased both yield and quality of grain. The vast area adaptable to wheat production, the "Great Plains" of Europe and Asia, extends East

and West across Central Europe and Asia and is about three times the extent of the similar area extending North and South through Central United States and Canada.

Land Rental or Tax and Grain Export Prices

The government demands a tax for the use of the land. Peasant, collective and trust farm alike must deliver annually a percentage of their crop to the government for the use of the land. The land is a natural resource and as such belongs to the government, there being no private ownership of real estate under the communistic regime; therefore, all using the land must pay this annual tax. Each peasant farmer must deliver this portion of his crop to the village collecting station and receive his tax receipt or he is subject to arrest and to the loss of his land for farming purposes.

The agricultural products collected by the government as a land tax form a principal source of the tremendous tonnage exported to meet the foreign debts. This mass of farm products which costs the government nothing to produce is sold abroad in competition with agricultural products of other countries. This is a tax on a natural resource, the cost of which involves only collecting and handling charges to the market. On this basis Soviet Russia can compete in agricultural products with any nation in the world so long as her natural resource, "the soil fertility", holds up, and there are vast new areas too dry for farming which will be opened up as irrigation projects are developed.

The surplus grain produced on the collective and trust farms is purchased by the government grain trust. This is paid for with rubles printed without cost to the government. This past year, due to favorable moisture conditions and the extensive industrialization of farming, the wheat production reached the pre-war level, or about 1,097,000,000 bushels, and barley, fruit, and cotton production was far beyond the pre-war level. The price paid for this grain is determined by a committee in advance of the sowing date. The same procedure is followed in relation to the fruit farms, the cotton farms and others producing agricultural crops. This is the principal source of cash income, other than the labor hired out from the collective farms, which these communistic units have for purchasing the food and clothing needed for the individuals or paying for the labor on the trust farms.

Scientist Increasing Quality and Yield of Wheat

The scientist has his part in the programme of this agricultural producing machine. New disease resistant, good quality varieties are being produced with the same drive as used in other lines of work. Last year such a wheat was ready for distribution and was sent out by the government through the area where it was adapted with orders to grow it on all of the farms. Those not growing it would have their fields ploughed up or taken away and given to more intelligent farmers. This year, throughout the vast winter wheat area, this one wheat, Ukrainka, was grown for the government with remarkable yields of a high quality wheat competing in disease resistance, hardiness and quality with the best wheats in America, again showing the effectiveness of this producing machine under complete gov-

ernment control. They are producing cheaper grain with this soil mining machine, but at a sacrifice of human individualism, human advancement and soil fertility. It is only a matter of time until the system must be modified to meet human demands as well as those of soil fertility.

Over-Production and Lowered Consumption

There is a general over-production of farm products and surplus of farm labor throughout the other grain and fruit producing countries of Europe. In the economic adjustment to meet these conditions, two important trends are especially worthy of mention. First, there will be the slowing up, if not abandonment, of the introduction of labor saving machinery on the farms. The crops, especially grain, produced are not sold for high enough prices to pay for the purchase of machinery, and labor is so plentiful and cheap that the use of costly machines cannot be justified. Bulgaria for example, after finding that 90 per cent of a group of farms fully equipped with farm machinery was not paying operating expenses including interest on the investment, is advising against purchasing machinery other than essential such as ploughs and drills. They are planning an extensive educational programme along this line through their government agricultural extension service. This lowered purchasing power in Europe pertains to other manufactured products as well as foods. And secondly, there is the introduction of special legislation in an attempt to protect the farmer from the importation of agricultural products which can be produced at home. For example, Sweden recently passed a law compelling the millers to use 80 per cent of home grown wheat for milling flour and to pay a stipulated price to the farmer for this wheat. The law also included a tariff on milled products from abroad. The other principal European countries except Denmark and England, have passed similar laws or placed tariffs on farm commodities. Thus, Soviet Russia, with untold natural resources in reserve, with a vast acreage of land under cultivation and others to be developed by irrigation, with the policy of exporting the best and using what is left at home, with the conversion of the individuals into massed machine producing units, with a printed currency for internal circulation produced without cost to the government, is forcing Europe into this rapid readjustment of her economic problems in agriculture.

The American agricultural surpluses and low prices of raw materials are causing adjustments in agricultural programmes in the United States and Canada. Many of these adjustments are temporary, but out of this depression period will evolve permanent advances in better balanced farm programmes and lower production costs, better and more direct marketing systems and an increased per capita consumption of the basic crops such as wheat.

American agricultural readjustment is possible without loss of individualism and without lowering the standard of living. Farm industrialization as found in Soviet Russia with the subsequent sacrifice of individual existence and of home life to the dictates of the mass will never meet the standards of living set by the Canadian or the United States farmer. Coöperation without the loss of individualism especially in relation to the

purchase and utilization of machinery and marketing of crops will help solve the problem by bringing about more efficient and economical production, distribution and marketing.

The solution of the problem depends upon the North American farmer. The high degree of intelligence of this large class of industrious people is sufficient assurance that the problem is being coped with and will be satisfactorily solved quite aside from whether the Soviet Russian agricultural programme is on a legitimate, economic basis, and whether permanent or temporary in its duration.

BOOK REVIEW

BEEKEEPING IN ANTIQUITY by H. Malcolm Fraser, Ph.D., B.A., London, England, (University of London Press Limited, 10 and 11 Warwick Lane, London, E.C. 4, 4/6 Net. Published in Canada by Clarke, Irwin & Company Ltd., $1.50.)

The early history of beekeeping is somewhat hazy at its best, for practical beekeepers of ancient times do not appear to have recorded their experiences or observations nearly so carefully as do beekeepers of modern times. This perhaps was due to the fact that little or nothing was known about the internal activity of the colony at that time. Moreover, most of the records that are available seem to have been written by men who gained their information from sources other than practical experience; it is even doubtful if Virgil, whose fourth Georgic is considered a classic on beekeeping, was ever a beekeeper himself. Furthermore, these ancient records cover a long period of time and a great many of them are inaccessible to most beekeepers of to-day because of their rarity and the language in which they were written. The author discovered this fact some years ago and set himself the task of collecting and bringing together in one book and in the English language as many of these ancient records as he possibly could and "Beekeeping in Antiquity" is the result. The book is good and worthy of a place on the bookshelves of every lover of beekeeping.

It would appear that the honey bee and her products were well known long before the time of Aristotle which is well shown in the first chapter of the book, but according to the author "Aristotle is the earliest author whose writings on beekeeping have been preserved." Aristotle was soon followed by others and the author has discussed each in chronological order, and in so doing has shown the development of beekeeping during the classical period.

In the light of modern beekeeping, there is a great deal of nonsense contained in ancient bee literature, while on the other hand much of it has stood the test of time. It would appear that some ideas which are supposedly modern were well known to the ancients, they used smoke to quieten their bees, queens' wings were clipped to retard swarming, colonies were requeened by transferring queen cells and feeding for winter was recommended. Bee diseases were apparently observed, but the cause was unknown.

"Beekeeping in Antiquity" is historical and offers to every beekeeper, who wishes to do so, an opportunity of studying some of the early history of his craft.

C. B. G.

THE DESTRUCTION OF ROPY AND BITTER MILK ORGANISMS BY HYPOCHLORITE

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In a previous paper (*Johns, 5*) the speed of germicidal action of chlorine compounds upon representative bacteria commonly occurring in milk was reported. It was pointed out that the germicidal value of a chlorine solution could not be judged merely by the available chlorine content, since the speed of action upon certain organisms was greatly influenced by the hydroxyl ion concentration. Since the employment of chlorine sterilization in combatting outbreaks of ropy milk is frequently recommended (*2, 3, 6, 7*), further studies were made upon the rapidity of destruction of representative organisms capable of causing ropy and bitter milk [2].

Methods

As the work previously reported (*5*) had shown the chloramine-T products to be unsuited to use as an instantaneous rinse, the present studies were confined to hypochlorites. The products employed were:

B-K—liquid sodium hypochlorite.

Diversol—sodium hypochlorite combined with tri-sodium phosphate.

H T H —calcium hypochlorite powder.

In the first two cases, the products were employed in the concentration recommended by the manufacturers. With H T H, a sodium hypochlorite stock solution was made up by adding straight 58% soda ash in the proportion of 3 parts to 4 of hypochlorite powder. The stock solution contained 2.64 per cent available chlorine at the start. This was diluted with sterile tap water in the proportion of 1:350 in preparing the rinse solution.

In determining the speed of destruction of the various test organisms, the plating technique described in the previous paper (*5*) was employed. In addition, for every four plating tests, a set of tests with sterile purple milk tubes was made, using a single drop of the inoculated hypochlorite solution as inoculum. These tubes were incubated at room temperature for two days, then examined for changes typical of the test organism employed.

The ropy organisms employed were:

No. 216 *Streptococcus lactis, var. hollandicus.*

" 217 *Achromobacter viscosum*

" 218 *Aerobacter* species

" 168 *Micrococcus* species

" 224 " "

[1] Assistant Agricultural Bacteriologist.

[2] The author wishes to acknowledge his indebtedness to Dr. A. G. Lochhead, Dominion Agricultural Bacteriologist, for suggesting these further studies, also for helpful advice in connection with the preparation of the manuscript.

The bitter organisms employed were:

No. 103 *Achromobacter* species

" 225 *Escherichia* species

Cultures Nos. 216 to 218 were kindly furnished by Dr. B. W. Hammer of Iowa State College. No. 225 was obtained from the Dairy Research Division, Dominion Dairy and Cold Storage Branch, Ottawa, having been isolated from pasteurized milk in the early spring of 1930. No. 168 was isolated during an epidemic of ropy milk at the Central Experimental Farm in 1927. No. 103 was isolated from a sample of bitter milk submitted by a manufacturer of baby food, while No. 224 was isolated from a plate poured from apparently normal milk from a farm having trouble with ropy milk.

In all cases the broth cultures used in inoculating the hypochlorite solutions were grown at room temperature for twenty-four hours. Culture No. 216 was grown in whey broth containing powdered $CaCO_3$ and plates poured using purple lactose agar (Difco). The remaining cultures were grown in nutrient broth and plated upon standard nutrient agar (Difco). All plates were incubated at room temperature for five days. Twelve sets of plates and three sets of milk tubes were prepared from all except No. 225, where only eight sets of plates and two sets of milk tubes were prepared.

The stability of the concentrated products was determined by titration at the start, and again after six months storage at room temperature. The strength of the rinsing solutions used in these tests was likewise determined at frequent intervals.

Results

The relative resistance of the various organisms to destruction by the three hypochlorites is shown in table 1. The percentage survival figures for each organism are the average of 12 tests (8 only for No. 225) while the milk tube data are the average of 3 tests (2 only for No. 225). Table 2 presents data concerning the strength of the rinsing solutions employed, and regarding the stability of the concentrated products when stored at room temperature for a period of six months.

Discussion of Results

From the data presented in table 1, it is evident that the less alkaline hypochlorites (B-K and H T H) are very effective in the destruction of all seven test organisms. With the more alkaline type (Diversol) certain organisms are destroyed quite rapidly, while others show varying degrees of resistance. It should be noted here that while the Diversol rinse made up according to directions was somewhat weaker than solutions of B-K and H T H (see table 2) this difference does not seem sufficient to explain the slower action of this product against certain organisms. For instance, in the studies previously reported (*5*), one strain of *Strept. lactis* showed 17.7 per cent survival after 60 seconds contact with a Diversol solution containing over 70 parts per million available chlorine. Incidentally, Tonney, Greer and Danforth (*11*) using chlorinated distilled water have shown that doses of free chlorine as low as 0.1 part per million have sufficed to destroy within 15 to 30 seconds the majority of the 235 strains

studied, while none was able to resist a concentration of over 0.25 parts per million of available chlorine. Consequently it appears unlikely that the lower concentration of available chlorine in a Diversol solution of the strength recommended by the manufacturer is the cause of the slower germicidal action of this type of hypochlorite.

TABLE 1.—*Effectiveness of hypochlorite solutions in the destruction of ropy and bitter milk organisms.*

Test Organisms	Gram Stain	Period of contact (Seconds)	Percentage of bacteria surviving treatment			Percentage of milk tubes showing typical growth in 48 hours		
			B - K	Diversol	H T H	B - K	Diversol	H T H
No. 216		15	0.0009	8.93	0.0	0.0	100.0	0.0
S. lactis var.		30	0.0	0.910	0.0	0.0	100.0	0.0
hollandicus	+	45	0.0	0.0231	0.0	0.0	66.7	0.0
(Ropy)		60	0.0	0.0051	0.0	0.0	0.0	0.0
No. 217		15	0.0	0.003	0.0	0.0	33.3	0.0
Achromobacter		30	0.0	0.0	0.0	0.0	0.0	0.0
viscosum	—	45	0.0	0.0	0.0	0.0	0.0	0.0
(Ropy)		60	0.0	0.0	0.0	0.0	0.0	0.0
No. 218		15	0.0	0.0	0.0	0.0	0.0	0.0
Aerobacter		30	0.0	0.0	0.0	0.0	0.0	0.0
sp.	—	45	0.0	0.0	0.0	0.0	0.0	0.0
(Ropy)		60	0.0	0.0	0.0	0.0	0.0	0.0
No. 168		15	0.0	1.87	0.0	0.0	100.0	0.0
Micrococcus		30	0.0	0.046	0.0	0.0	66.7	0.0
sp.	+	45	0.0	0.0	0.0	0.0	66.7	0.0
(Ropy)		60	0.0	0.0	0.0	0.0	0.0	0.0
No. 103		15	0.0	0.232	0.0	0.0	0.0	0.0
Achromobacter		30	0.0	0.025	0.0	0.0	0.0	0.0
sp.	—	45	0.0	0.024	0.0	0.0	0.0	0.0
(Bitter)		60	0.0	0.011	0.0	0.0	0.0	0.0
No. 224		15	0.0	14.0	0.0	0.0	100.0	0.0
Micrococcus		30	0.0	1.64	0.0	0.0	100.0	0.0
sp.	+	45	0.0	0.102	0.0	0.0	100.0	0.0
(Ropy)		60	0.0	0.0083	0.0	0.0	66.7	0.0
No. 225		15	0.0	0.0	0.0	0.0	50.0	0.0
Escherichia	+	30	0.0	0.0	0.0	0.0	0.0	0.0
sp.	—	45	0.0	0.0	0.0	0.0	0.0	0.0
(Bitter)		60	0.0	0.0	0.0	0.0	0.0	0.0

TABLE 2.—*Data concerning strength of rinsing solutions and stability of concentrated products.*

Product	Available chlorine at start	Available chlorine after 6 months	Average strength of rinsing solution p.p.m.
B - K	3.14%	2.90%	81
Diversol	2.97%	2.89%	55
H T H (stock solution)	2.64%	2.50%	75

In table 1 it will be noted that the most marked resistance towards the more alkaline type of hypochlorite solution is exhibited by the Gram-positive organisms. The relation between the Gram character of an organism and its resistance to the action of oxidizing agents has been discussed in a recent paper by Stearn and Stearn (*9*). Although chlorine compounds were not among those studied, it was found that, on the whole, Gram-positive organisms were less susceptible to oxidizing agents than Gram-negative. This is in accord with the results reported here and in the previous paper, while similar indications may be found in the data reported by Hilliard (*4*) Dienert & Etrillard (*1*), Tilley (*10*), and Tonney, Greer and Danforth (*11*) regarding resistance to chlorine.

Certain fundamental differences between Gram-positive and Gram-negative organisms have been catalogued by Smith (*8*). On the basis of optimum pH, ability to form spores, and sensitivity to dyes, non-electrolytes, lysis by sodium hydroxide and peptic digestion, there is a fairly clear-cut differentiation between the two groups. It seems probable that resistance to destruction by hypochlorite is another point wherein the two groups differ, although here, as in some of the other features noted by Smith, certain irregularities may be observed. For instance, in the present studies, Culture No. 103, a Gram-negative organism, showed greater resistance than No. 225 as measured by the plating technique, although the latter was distinctly Gram-variable on a number of different tests. As judged by the milk tube tests, however, the reverse appears to be the case. No doubt in a study of a large number of strains of different species certain anomalies might be encountered; nevertheless, it is highly probable that in general the degree of resistance exhibited by Gram-positive bacteria would be greater than that shown by Gram-negative species.

The influence of the pH of the solution upon the speed of destruction of bacteria by hypochlorites was referred to in the previous paper (*5*), and data advanced to show that decreasing the hydroxl ion concentration of a Diversol solution greatly increased the speed of germicidal action and similarly the degree of corrosiveness. If the destruction of the bacterial cell by hypochlorite is an oxidation process, the bactericidal power of such a solution might well be expected to decrease with increasing alkalinity, since the oxidation potential of an oxidation-reduction system is known to decrease with increasing pH values. On the other hand, the view is held in some quarters that the destruction of the bacterial cell by hypochlorite is a process of chlorination rather than oxidation. In this connection, Wright (*12*) has stated that alkalinity increases oxidation of substances by hypochlorite, while acidity hastens chlorination. Wright's work, however, was done with solutions of amino acids and proteins, and there appears to be no good reason for supposing that his results apply equally well to bacterial cells in suspension.

As was previously pointed out (*5*), the suitability and effectiveness of chlorine products in sterilizing dairy utensils on the farm has been the primary interest in the studies conducted at this laboratory. From this standpoint, the slight differences in stability of the concentrated products when stored at room temperature (table 2) are of minor importance, since under normal conditions the supply would be consumed within the six

months period. It is of interest to note that in these tests Diversol proved somewhat more stable than the liquid products, while in the previous studies the reverse held true. This improved stability is in all probability due to a change in the type of package of Diversol. In the former studies this product was packed in a fibre container, while the latest supply came in a lacquered metal container. Tests have shown that this product retains its strength much more satisfactorily when packed in an air-tight container.

While Diversol is decidedly less corrosive than the more active types of hypochlorite, this feature is of minor importance on the farm. Since a hypochlorite rinse is generally employed to sterilize dairy utensils immediately before milking, no measurable degree of corrosion is likely to take place between the time of sterilizing and the employment of the utensil as a milk container, as laboratory tests with tinned metal strips have proven.

It might not be out of place to mention that the very slow rate of solution of Diversol in cold water makes this product decidedly inconvenient for farm use, particularly for the morning milking.

Summary

A study has been made of the relative efficiency of solutions of three hypochlorite products in the destruction of five ropy and two bitter milk organisms.

The less alkaline hypochlorites proved to be extremely effective against all seven test organisms. Against the more alkaline product, however, the Gram-positive species exhibited varying degrees of resistance.

No marked differences in stability were found when the concentrated products were stored at room temperature for six months.

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PHOSPHORUS STUDIES ON ALBERTA SOILS

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During the past five years various fertilizer experiments have been started by the Soils Department of the University of Alberta.[2] In general these experiments have been confined to the gray or wooded soils which constitute the major portion of the unsettled lands of Alberta, and also are the soils that show the greatest response to fertilizers, even when they have been cropped for only a few years (*9, 10*). The experiments with phosphatic fertilizers were extended several years ago to include soils in the black and transitional belts.

Various laboratory investigations have been carried out with the different soils, chiefly dealing with the soluble phosphorus. As similar problems are being studied at other points throughout the west our results may be of value to the investigators working with similar soils.

In this report we have included data from three types of soil: gray, black and transitional. The gray soils are representative of the heavily leached podsolic soils that extend over the northern half of the province. The black soils are typical loams from the Edmonton district. The transitional soils are from the belt that lies between the black and gray soils and has characteristics of both.

Table 1 shows the different types of soils used and their response to phosphatic fertilizers if known.

Table 1.—*Soils used and responses to fertilizers.*

Soils	Group	Response
1	Black.....cultivated	no
2	" ..... "	yes
3	" .....virgin	.....
4	Transitional.....cultivated	responds to $(NH_4)_3PO_4$
5	" ..... "	yes
6	" ..... "	no
7	" ..... "	slight
8	Gray..... "	responds with legumes
9	" ..... "	responds to $(NH_4)_3PO_4$
10	" .....virgin	.....

The material used for analytical purposes was representative of the plow depth in all cases.

Methods

The samples were analyzed for total phosphorus, water soluble phosphorus and for phosphorus soluble in .002N H_2SO_4. Results are reported in table 2.

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[2] Grateful acknowledgment is made to Dr. F. A. Wyatt for advice and criticism during the investigation.

Total phosphorus was determined by the method outlined by Mather (*4*) for use with soils. This is an adaptation of the Fiske and Subbarow colormetric method.

Extracts for soluble phosphorus were made by placing the desired proportions of soil and solution in a shaker bottle, which was placed on an end-over-end shaker for thirty minutes. The solution was then filtered on a Buechner funnel using suction. The first portion of the filtrate which was generally turbid was returned to the filter. The phosphorus in the extracts was determined by the Deniges colormetric method as modified by Parker (*5*). The Deniges method is more sensitive than the Fiske and Subbarow and is better suited for determinations in dilute solutions. The method varied from that recommended by Parker in that the reducing solution was made by dissolving $SnCl_2$ in a solution of HCl as outlined by Truog (*8*). This solution was kept in an atmosphere of hydrogen and under such conditions can be kept for at least two weeks. Owing to the fact that all H_2O extracts were colored with organic matter it was necessary to evaporate the solutions and then ignite using $Mg(NO_3)_2$ to aid in the oxidation. The above procedure reduces all the inorganic and organic phosphorus to the phosphate form, so that all results are for total phosphorus in solution. As plants use phosphorus only in the form of the PO_4 ion the above procedure would include some soluble phosphorus that was not readily available to the plant.

The analyses show that the total phosphorus varies from .109 per cent to .046 per cent with the three black soils at the top of the list and a gray at the bottom. The above figures are fairly representative of the different types of soil.

TABLE 2.—*Total, water soluble and readily available phosphorus in soils.*

Soil	Group	Total P. %	Extracts	
			1-5 water p.p.m.	1-200 .002N H_2SO_4 p.p.m.
1	Black	.091	2.0	36.5
2	"	.084	1.2	16.0
3	"	.109	5.6	41.2
4	Transitional	.061	1.6	40.5
5	"	.062	3.7	97.0
6	"	.054	4.7	75.7
7	"	.055	2.0	34.0
8	Gray	.075	2.7	83.5
9	"	.046	1.1	39.2
10	"	.066	1.8	71.8

Water extracts in the proportion of 1-5 were made and the phosphorus determined as outlined above. Table 2 gives the results reported as p.p.m. phosphorus dissolved from the soil. In comparing the water soluble with total phosphorus we find that there is no relationship between them. Soils 4 and 5 have approximately the same totals but 5 has twice as much water soluble phosphorus. Similar conditions are found in soils 6 and 7. In the case of 2 and 9 the water soluble is the same but 2 has

almost twice as much total phosphorus. Reporting the above figures for water soluble phosphorus as p.p.m. PO_4 they vary from approximately 3.3 to 16.8. These figures are in general higher than those reported by other workers for soils that respond to phosphatic fertilizers. Tidmore (*7*) reports soils which contain less than .25 p.p.m. PO_4 in the displaced solution that are yielding good crops of corn. It is doubtful if such a concentration would be sufficient for similar crops under the climatic conditions found in Alberta, where there is a short growing season with long hours of sunshine.

For the purpose of comparison, the readily available phosphorus was determined by the Truog method (*8*). Results are reported in table 2. To place these results on the basis of pounds of phosphorus per acre, multiply the p.p.m. by 2. Truog adopted the quantity of 75 pounds per acre as the lower limit for soils that did not respond to phosphorus fertilizers. Of the above soils, 1, 2 and 7 fall below the required amount; 1 is near the limit and does not respond, while 2 which is very low responds to all phosphorus applications. Soil 7 gives a slight response but not as much as 9, which is slightly above the limit. Very little response to superphosphate is shown by 4, but profitable returns are secured from 5 which has double the amount of available phosphorus. Alfalfa on 8 responds vigorously to superphosphate. No relationship was found between the readily available phosphorus and the response to phosphatic fertilizers.

The soils were also tested by the method developed by Bray (*1*) and were all high, even 2 showing a fair amount of phosphate.

It is evident that these soils are in general high in easily soluble phosphorus irrespective of the standard by which they are measured. This may be due to the fact that they they are comparatively new in point of years of cultivation, but this does not account for the fact that many of these soils respond to phosphatic fertilizers. Climatic conditions, especially the long hours of sunshine during the growing season, may be an important factor.

In order to gain some knowledge of the form in which the easily soluble phosphorus was held in the soils, they were leached with solutions of various pH values. HCl was used for the acid range and NaOH for the alkaline. A series of eight samples of each soil was set up and then acid or alkaline solutions added in the proportion to give a 1-5 extract. After shaking for 30 minutes the solutions were filtered and the pH of the filtrate determined. An aliquot of the solution was used for the determination of the phosphorus content. The results for four soils are plotted in figure 1 using p.p.m. PO_4 as ordinates and pH values as abscissae.

The normal pH value of all these soils falls between pH 6 and pH7. As equal amounts of acids or alkali were added to each soil some idea of the comparative buffer capacities can be obtained by comparing corresponding points on the different curves.

The elements that are the most important in fixing phosphorus in the soil are iron, aluminum, calcium and magnesium (*2*) (*6*). In addition we have phosphorus tied up with the organic matter.

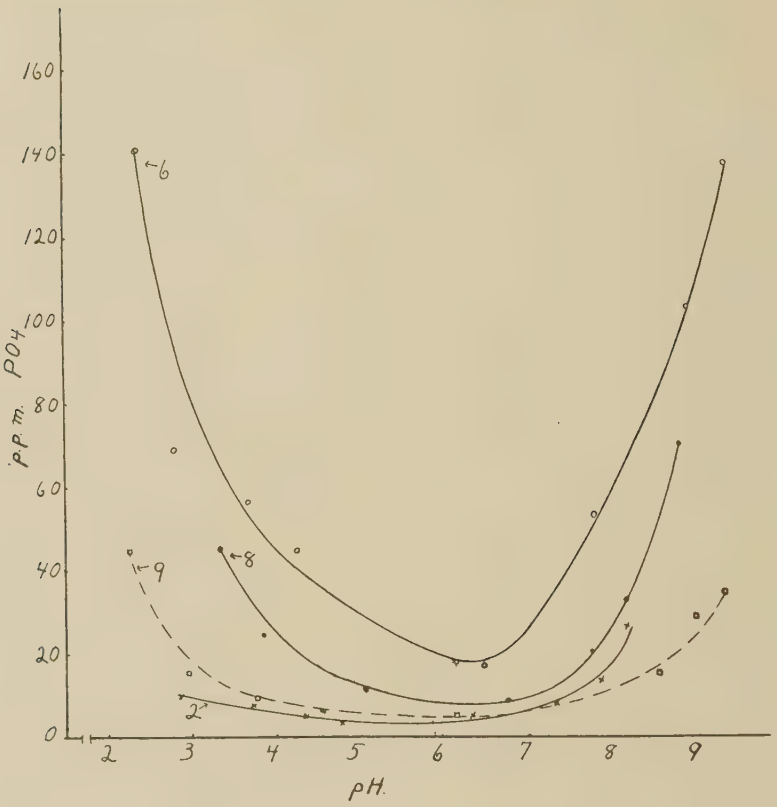

Figure 1. Effect of change in pH on soluble phosphorus.

Ferric phosphate has its point of minimum solubility near pH 3. More acidic conditions give complete solubility while any change toward the alkaline side results in the hydrolysis of the $FePO_4$. Aluminum phosphate reacts in much the same way, the point of minimum solubility being about pH 6. Calcium phosphate is precipitated between pH 6 and pH 7 and does not hydrolyse at higher pH values. The organic compounds are more readily broken down in alkaline solutions.

From a curve plotted so that it shows the soluble phosphorus over a wide range of pH values for a given soil we arrive at the following conclusions. An increase in phosphorus on the alkaline side can be attributed to the hydrolysis of iron, aluminum or organic compounds. If iron and aluminum are responsible, then the increase will be reflected at the acid end of the curve. The precipitating effect of calcium is prevented to a greater or less extent in alkaline solutions by the presence of organic matter. Analysis of alkaline extracts of peat soils showed calcium and phosphorus in solution at pH 10 (*2*). An increase in soluble phosphorus between pH 6 and pH 7 indicates calcium and magnesium phosphates. The presence of these may be masked by the reprecipitation of the phosphorus by iron and aluminum. Increases between pH 6 and pH 3 are attributed to aluminum compounds, while an increase below pH 3 is caused by iron compounds.

Curve 2 in figure 1 shows the soluble phosphorus in soil 2 at various pH values. This soil is high in organic matter and total phosphorus. The curve indicates a higher buffer capacity than the other soils for there is less change in pH. Compare corresponding points on the different curves which indicate solutions of same original pH. There is very little change in the amount of soluble phosphate from pH 6.4, (the natural pH of the soil) to pH 2.9. This indicates that very little of the phosphorus is readily soluble in dilute acid. The curve on the alkaline side indicates about three times as much phosphorus in solution at pH 8.2 as at pH 6.4. This is mostly organic phosphorus for the curve shows that there is very little iron or aluminum phosphate to hydrolyse. The curves 6, 8 and 9 for the corresponding soils show more readily soluble iron and aluminum compounds as measured by the amount in solution on the acid side of pH6. This is again reflected on the alkaline side by an increase in the range where iron and aluminum phosphates hydrolyse. Soils 6, 8 and 9 are low in organic matter.

The question arises as to the advisability of increasing the alkalinity of these soils and thus increasing the soluble phosphorus. These soils can all be shifted to pH 7.4 by the addition of 1-3 tons per acre of marl, but the increased calcium content would tend to decrease the soluble phosphorus. The cost of applying the marl would be more expensive than the application of super-phosphate, though the effect might be more lasting in the former.

The ability of the above soils to fix PO_4 was tested by treating 20 gms. of soil with 100 cc. of solution containing 5 mgm. PO_4 in the form of KH_2PO_4. The samples were shaken for one hour and allowed to stand overnight. The solutions were then filtered and the PO_4 content determined. Table 3 gives the PO_4 fixed by the different soils.

The application was equal to 250 p.p.m. or 500 pounds per acre of PO_4 or about 800 pounds per acre of treble superphosphate which is approximately 8 times the advised field application. The above experiment indicates that these soils would fix immediately all the phosphate applied in an ordinary field application.

TABLE 3.—*Fixation of phosphorus by the different soils.*

Soil	mgm. PO_4 fixed per gm. soil	% of application fixed
1	.209	80.3
2	.206	80.2
3	.180	72.0
4	.148	50.9
5	.116	66.4
6	.148	50.9
7	.186	70.4
8	.214	85.5
9	.212	84.8
10	.214	85.5

The solubility of this fixed phosphate was not determined. As the fixation was accompanied by an increase of .4 to .6 in pH, all the extracts being on the alkaline side after filtering, the fixation was likely caused by

the precipitation of calcium phosphate instead of iron and aluminum. Work by Holowaychuk (*3*) on the replaceable bases in the above soils indicates that they contain large quantities of replaceable calcium.

The rate of depletion of the soluble phosphorus in the above soils was studied in the following manner—20-gm. samples were leached on a Buechner funnel until 100 cc. of filtrate was obtained. The moist sample was then placed in a jelly jar and left until the next leaching when the process was repeated. The results are reported in table 4 as p.p.m. PO_4 dissolved from the soil.

TABLE 4.—*Effect of periodic leaching on water soluble phosphorus.* (*p.p.m. PO_4*).

Soil	Feb. 2	Feb. 3	Feb. 9	Feb. 12	Feb. 16	Feb. 19	Total
1	6.6	2.9	2.0	1.9	1.6	1.4	16.4
2	3.9	0.9	0.6	0.9	1.2	0.5	8.0
3	13.0	4.4	3.8	3.3	5.4	2.2	32.1
4	4.6	2.2	1.2	1.5	1.3	1.1	11.9
5	11.0	8.8	7.0	6.8	14.0	5.8	53.4
6	16.8	6.8	6.0	6.6	5.6	5.1	46.9
7	4.9	2.2	1.3	1.2	1.2	1.4	12.2
8	8.6	4.6	2.5	4.4	3.0	2.5	25.6
9	4.3	1.6	1.3	2.0	1.4	0.9	11.5
10	5.0	4.5	3.3	2.2	3.4	1.7	20.1

The soils were all rapidly depleted of water soluble phosphorus, the second leaching being from 25 per cent to 75 per cent of the first, after which the decrease was much slower. The amount of total phosphorus, table 2, has little or no effect on the rate of depletion. Soils 5 and 6 have the highest concentration in the final extracts but are much lower in total phosphorus than 1, 2, 3 and 8. Furthermore, there is no close relationship between the total phosphorus removed by six extractions with water and the amount removed by the first extraction.

To determine the effect of time on the solubility of applied PO_4 the following series was set up using a gray soil. All applications are on the acre bases.

1. Check.
2. 3 tons marl.
3. 3 tons marl and 200 lbs. super-phosphate.
4. 200 lbs. super-phosphate.

Five duplicates were set up with each treatment and one from each series was analyzed at month intervals, the first being extracted immediately after mixing with the fertilizer. The jars were kept moist during the time of the experiment. The extractions were on the basis of 1-5 and the PO_4 is reported as p.p.m. in the soil.

We find that the lime has depressed the solubility of phosphorus as compared with the check, but that where lime and phosphorus were applied, there is not much difference. The application of super-phosphate alone has materially increased the PO_4 in solution when first applied, but there has been a slight decrease in solubility with time. The phosphate was fixed immediately and remained in an insoluble form.

TABLE 5.—*Effect of time and treatment on the solubility of applied phosphorus.* (*p.p.m. PO_4*).

Treatment	Month				
	0	1st	2nd	3rd	4th
Check	1.5	1.05	3.2	1.5	1.4
3 tons marl	.55	.67	.87	.77	1.8
3 tons marl and 200 lbs. super-phosphate	1.6	1.25	1.5	1.4	1.45
200 lbs. super-phosphate	3.3	2.3	2.5	2.2	1.9

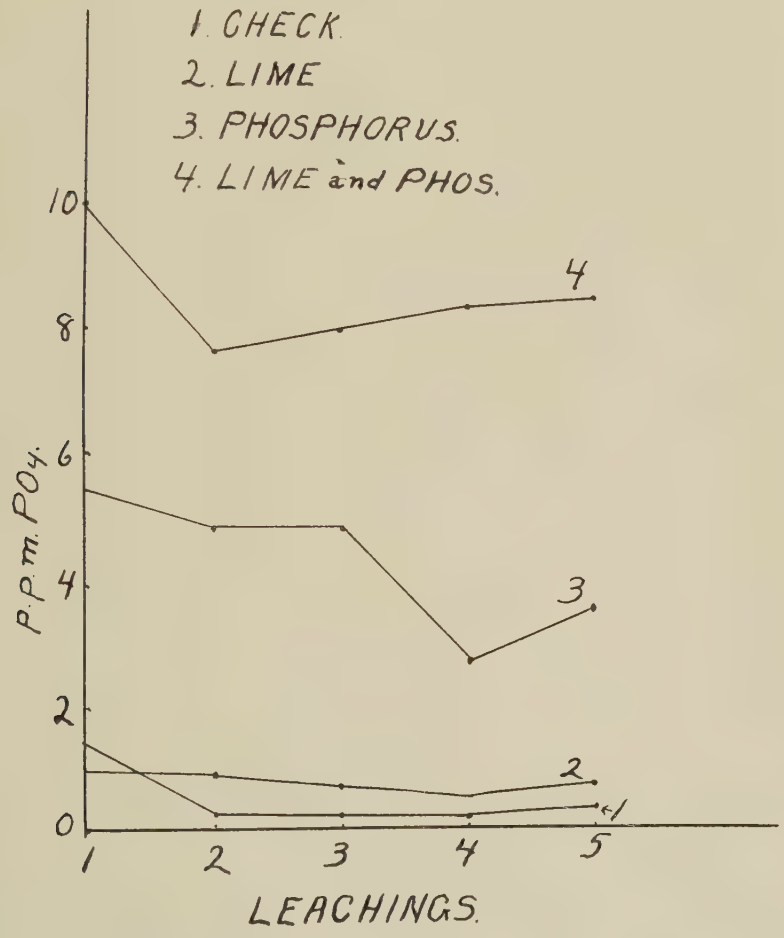

Figure 2. Effect of treatment on water soluble phosphorus. Samples leached at weekly intervals.

Further evidence of the effect of lime and phosphatic fertilizers on the soluble phosphorus in a gray soil was obtained by leaching samples of soil at weekly intervals for a period of five weeks. Samples of soil were secured from plots that had been treated several years previously with the following material:

1. Check.
2. Lime.
3. Super-phosphate.
4. Lime and super-phosphate.

Fifty gram samples were leached on Buechner funnels until 100 cc. of filtrate were secured. The moist samples were then placed in jelly jars and kept moist until the next leaching. The filtrate was analyzed for phosphorus and the results plotted in figure 2.

The check drops from 1.4 p.p.m. to .28 p.p.m. at the end of the first week and remains at this low figure throughout the experiment. The limed plot is slightly lower than the check for the initial leaching, but maintains a higher concentration than the check for the rest of the experiment. The phosphorus-treated soil shows a decided increase which is maintained for the first three leachings but then drops off, but it is still well above the check. The plot treated with lime and super-phosphate has the highest initial content and remains much above the other curves throughout the experiment. The pH of the extracts from the lime plots varied from pH 7.1 to pH 7.4 while the check plot varied from pH 6.0 to pH 6.3 and the phosphorus treated from pH 5.8 to pH 6.4. The extracts from soils 1 and 3 showed a tendency to become more alkaline as the experiment proceeded. Analysis of the plants grown on the limed and check plots showed that while the per cent of phosphorus in the plants was approximately the same, the plants on the limed plots had removed more phosphorus than on the check (*10*). The increased PO_4 at the higher pH values may be caused by a hydrolysis of aluminum and iron phosphatic compounds.

Summary

Data has been presented showing that the soils investigated are in general high in water soluble or available phosphorus. Many of these soils are showing response to phosphatic fertilizers.

The water soluble and available phosphorus found in these Alberta soils is high when compared with standards set by Bray and Truog.

Analyses were carried out to determine if there were any apparent relationship between total and water soluble or available phosphorus. No close relationship was found.

Curves were presented showing the easily soluble phosphorus at various pH values for four different soils. The relationships between the curves and the phosphatic compounds of the soil are pointed out. Iron, aluminum and organic compounds are responsible for most of the soluble phosphorus.

The rate of depletion of the water soluble phosphorus was studied in ten different soils by subjecting samples to bi-weekly leaching. Results show a rapid depletion of the water soluble phosphorus. No relation was found between total phosphorus and the concentration of final leaching.

The effect of lime and super-phosphate upon the water soluble phosphorus of a gray soil was determined. Super-phosphate alone, or lime and super-phosphate increased the soluble phosphorus.

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CONCERNING THE C.S.T.A.

Report of the Meetings of the Soils Section at the Annual Convention of the C.S.T.A.

Chairman—Doctor R. Harcourt

Secretary—Professor G. N. Ruhnke

The first session of the Soils Group on Tuesday afternoon was opened by a few introductory remarks by the Chairman and four papers on soil fertility were presented.

On Wednesday morning the second session took place, at which four papers on soil formation and classification were presented. At both sessions great interest was displayed in all topics as evidenced by the spirited discussions which followed their presentation. Unfortunately, there was insufficient time available for as full discussion as might be desired. Owing to the limited time and the absence of Professor A. H. Joel, of Saskatchewan, and Mr. J. L. Doughty, of Alberta, their respective papers were not read.

On Friday morning, Dr. G. N. Hoffer, of Lafayette, Indiana, addressed the section on "Diagnosing Soil Deficiency." His talk was illustrated by actual tests made on soils and plants taken from the College pasture experimental plots, as well as with lantern slides showing the symptoms of nutrient deficiency and the application of the tests in parts of the United States.

During the course of the Tuesday afternoon session the matter of organizing a permanent Soils Section of the C.S.T.A. came up for discussion.

A motion by Professor Ellis, seconded by Mr. F. F. Morwick, that a committee be appointed at this time to consider how the organization should be brought about was carried.

The report of the committee under the Chairmanship of Professor J. H. Ellis follows herewith.

At the initial "Soils Section" meeting, under the chairmanship of Dr. Harcourt, called by the official programme of the eleventh annual convention of the C.S.T.A., a resolution was moved, seconded and duly carried:—

"That a Soils Section of the C.S.T.A. be formed of the members interested in soil science."

The committee appointed at that meeting to suggest how this may be accomplished reports as follows:—

1. That to ensure the organization of a soils group within the C.S.T.A. satisfactory to all the members who may be interested throughout the Dominion, we would recommend a tentative organization to be formed for the ensuing society year.

2. That this tentative organization should appoint as an executive committee, three provisional officers.

   1. A chairman.
   2. A vice-chairman, one of which should be resident in the east and one in the west.
   3. A secretary, who should be located in the province where the next annual meeting of the C.S.T.A. will be held.

3. That this executive take the necessary steps to ensure a soils session at the time of the next annual meeting at which provision will be made to deal with the formation of a permanent organization of Canadian Soil Scientists, and papers dealing with soil research and problems may be presented.

All of which is submitted to the meeting for approval.

J. H. Ellis, Chairman.
B. L. Emslie,
G. N. Ruhnke,

The report of the above committee, appointed by Dr. Harcourt, was read at the Wednesday morning session of the Soils Section and, on a motion by Professor Ellis, seconded by Mr. F. Morwick, was adopted as read.

The results from the nominations and election are as follows:

President of the Soil Section—Professor J. H. Ellis, Manitoba Agricultural College.
Vice-president—Professor G. N. Ruhnke, Ontario Agricultural College.
Secretary—Professor A. H. Joel, University of Saskatchewan.

CURRENT PUBLICATIONS

1. Selling Ontario Fruit in Europe Through the Fruit Growers' Representative

This bulletin, prepared by A. Fulton, Commercial Representative of the Ontario Fruit Growers' Association, is issued through the office of the Agent-General for Ontario, 163 Strand, London. Many bulletins and articles have been written on the subject of grading and shipping fruit to Great Britain and this bulletin covers some of the same ground, using illustrations of good and bad examples of shipping. The part which should be of particular interest is the report of the system of direct selling through the Fruit Growers' own representative instead of through commercial houses. Mr. Fulton gives an account of his success in securing lower handling charges, more efficient transportation in the United Kingdom, and trans-shipment to the Continent. The advantages of the cash advance to growers made available by the Ontario Government and the advantages of a Provincial mark are also discussed. This bulletin should be studied by extension and administration officers who are dealing with districts where co-operative marketing of fruit is in practice or prospect.

2. The Availability of the Nitrogen in Farm Manure Under Field Conditions

In an article in the June, 1931 issue of *Soil Science* (Vol. XXXI, No. 6), A. Floyd Heck of the Department of Soils, University of Wisconsin, reports the following results from a field study of the availability of the nitrogen in cattle manure used on spring barley:

"The amount of nitrogen recovered in the barley crop was never greater than the amount of ammonia or liquid manure nitrogen applied. The results indicate that only the ammonia or liquid manure nitrogen is available for the first crop after the manure is applied to the soil. Little if any of the water-insoluble nitrogen in the manure is recovered in the first crop.

"Complete manure turned under immediately on spreading gives a recovery of 80 per cent of the urea or ammonia nitrogen which it contains. There is no difference in the availability of nitrogen between the manure fermented in storage and the fresh manure when they are turned under immediately on spreading.

"Top-dressing gives a higher availability than ploughing down. The nitrification of manure top-dressed and disked in is more rapid than when it is ploughed under.

"Measured in terms of non-recovery, the greatest loss of nitrogen in spreading manure and allowing it to dry or partially dry before being ploughed under, occurs with manure which has ammonified but not fermented. The next greatest loss is from the completely fermented manure. The fresh manure gives a still smaller loss under these conditions, and where the fermented manure is spread just previous to a rain the loss from drying is not more than a few per cent. The better the conditions for drying and the greater the proportion of the nitrogen in the form of ammonium carbonate, the greater the loss of nitrogen in handling, spreading and subsequent drying".

3. Grasshopper Control in Canada East of the Rocky Mountains

This bulletin by Norman Criddle of the Dominion Entomological Laboratory, Treesbank, Man., appears as No. 143 of the New Series of Dominion of Canada Department of Agriculture bulletins, available from the Publications Branch, Ottawa. Practical methods of control are discussed, with particular emphasis placed on the fact that the time of applying poison baits is of more importance than the exact ingredients, and that success or failure in their application is largely a matter of temperature. The optimum range of temperature is from 68°F. to 90°F. and on no account should baits be spread on cold or cloudy days.

For the information of extension leaders in control campaigns a technical section of the bulletin gives a key for identification and special notes on individual species of grasshoppers.

4. Humanity Uprooted, by Maurice Hindus (Published by Jonathan Cape and Harrison Smith, New York, Price $3.50).

This book and a later volume, "Red Bread" by the same author, are listed in the August accessions to the Library of the Department of Agriculture, Ottawa, and are available for loan to C.S.T.A. members. In the large list of books on contemporary

Russia,. "Humanity Uprooted" is considered the outstanding contribution from a non-partisan standpoint. Those who are interested in securing a proper background for consideration of the value of current articles on the Russian situation should study these two books. Of the first, Dr. Nicholas Murray Butler, President of Columbia University says:

"Now, whether one likes it or not, whether one sympathizes with it or not, the fact is there are one hundred and forty millions of people experimenting with this alternative mode of economic or social or political control. The most illuminating, helpful book that has been written about it all has the title, *Humanity Uprooted*".

The book is divided into three sections entitled "Institutions", "People" and "Quests". In the first section are discussed religion, property and the family; from the second one gets some understanding of the characteristics of the various classes of people which go to make up the nation; the third gives an idea of the international political factors at work and of the aims and hopes of the Communist Party for world revolution. The author takes many illustrations from current literature in the English language which enable one to compare the Russian viewpoint with ours.

5. A Method of Application Designed to Insure Proper Distribution of Fertilizers in Field Trials with Fruit Trees.

In an article in the May, 1931, issue of *Soil Science* (Vol. XXXI, No. 5), L. R. McKinnon and Omund Lilleland of the University of California report a method of overcoming the difficulty of getting a proper distribution of various salts throughout the soil mass where their effect is being studied on relatively deeply rooted deciduous fruit trees. Surface applications of fertilizer may never effect any chemical change in the mass of soil in which the major portion of the tree roots is found, due to the fixation of most of the salts in the top few inches of soil. To overcome this in the case of potash the fertilizer was dissolved in the ordinary power spray tank and pumped into the soil by means of injecting a rod made of ordinary pipe to a depth of three feet. In the experimental field work it was possible to distribute 50 gallons of solution over 200 square feet in fifteen minutes with two men each using a rod. Chemical analysis after this operation showed that this method of increasing the potash content in the lower depths of the soil was exceedingly effective. This method is particularly valuable in studying the effects of fertilizer on disease conditions in deep rooted fruit trees.

6. Jams, Jellies and Pickles

This appears as Pamphlet No. 137 by Miss Edith Elliot of the Fruit Branch, Dominion Department of Agriculture, and may be secured from the Publications Branch, Ottawa. Miss Elliot gives in concise form recipes for about sixty varieties of fruit butters, conserves, jams, jellies, marmalades and preserves. C.S.T.A. members who are interested in these additions to the family menu should secure copies of this pamphlet.

7. Biology in Human Affairs. (Edited by Edward M. East).

This volume, published by the McGraw-Hill Book Company, New York, is the latest contribution from Whittlesey House, a division of this company, which seeks to publish scientific books covering fields of interest to lay readers. The great contribution to human affairs made by the science of biology is discussed in twelve chapters written by outstanding authorities in each field. The chapters and authors are as follows:

1. Biology and human problems. Dr. Edward M. East, Harvard University.
2. The prospects of the social sciences. Dr. Frank M. Hankins, Smith College.
3. The renaissance of psychology. Dr. Joseph Jastrow, University of Wisconsin.
4. Educational psychology. Dr. Lewis M. Terman, Stanford University.
5. Psychology in industry. Dr. Walter V. Bingham, Personnel Research Federation.
6. Heredity. Dr. Edward M. East, Harvard University.
7. The frontiers of medicine. Dr. Morris Fishbein, Rush Medical College.
8. The outlook of public health work. Dr. Hugh S. Cumming and Dr. Arthur M. Stimson of the United States Public Health Service.
9. Physiology of today. Dr. E. Kennerly Marshall, Jr., Johns Hopkins University.
10. Zoology and human welfare. Dr. Howard M. Parshley, Smith College.
11. Efforts to increase the food resources. Dr. Donald F. Jones, Connecticut Agricultural Experiment Station.
12. Diet and nutrition. Dr. Elmer V. McCollum, Johns Hopkins University.

This book may be obtained from the Department of Agriculture Library, Ottawa, or through the C.S.T.A. Text Book Club at $3.50.

NOTES AND NEWS

F. B. Hutt (Toronto '23) has been appointed Professor of Animal Genetics at the University of Minnesota.

V. S. Asmundson (Saskatchewan '18) Associate Professor of Poultry Husbandry, University of British Columbia, has been awarded the research prize of the Poultry Science Association for 1931. The winning paper was on "The formation of the hen's egg", which appeared in the May, June and July, 1931 issues of *Scientific Agriculture.*

E. C. Hope (British Columbia '28), Assistant Professor of Farm Management, University of Saskatchewan, was married on August 10th to Miss Edna Mabel Cunningham of Alliston, Ont.

H. B. Sommerfeld (Saskatchewan '21) has returned from the University of Minnesota to the Manitoba Agricultural College.

H. W. Lohse (Copenhagen '25) has changed his address to Chemical Department, Ontario Agricultural College, Guelph, Ont.

J. L. Howatt (McGill '29) has changed his address to Dominion Experimental Station, Fredericton, N.B.

F. Laughland (McGill '21) has changed his address to c/o Saskatchewan Registered Seed Growers, Moose Jaw, Sask.

W. V. Longley (Toronto '11) has completed his thesis and has been awarded his Doctor's degree by the University of Minnesota.

P. N. April (Laval '15), formerly Agronome for Chateauguay County, has been appointed District Inspector of Agronomes and has also been elected Mayor of his parish.

Stanley Wood (Toronto '23), formerly Assistant Live Stock Superintendent for New Brunswick, has been appointed Live Stock Superintendent.

M. P. Harrison (Toronto '30), formerly Agricultural Representative at Gagetown, N.B., has been appointed Assistant Live Stock Commissioner for New Brunswick.

The following student members have advised their changes of address as follows:

F. S. Nowosad, General Delivery, Cowansville, P.Q.
R. M. Sketch, 1445 Bishop Street, Montreal, P.Q.
R. A. Boothroyd, c/o Tobacco Division, Central Experimental Farm, Ottawa.
J. E. Dubé, Bureau des Agronomes de Rimouski, P.Q.

CHANGES IN SCIENTIFIC AGRICULTURE

With the publication of this issue *Scientific Agriculture* enters its twelfth volume. This has seemed a suitable time to put into effect a few changes in form which have been considered for several months.

A new style of type has been adopted. While the old style of type was quite satisfactory on soft paper it did not stand out on coated paper as well as the new style. This may be easily seen by comparing last month's issue with this one.

A change in the size of type has also been made in the non-technical pages of the magazine. The section entitled "Concerning the C.S.T.A." and the new section "Current Publications" will be printed in the next size smaller type than that used for the technical articles. There should be no difficulty in reading this as it is the size with which everyone is familiar in the daily newspapers and in many current periodicals. The use of this size of type will allow us to get one-third more material in the same space without extra cost.

The new section entitled "Current Publications" will appear from month to month. It is hoped that this will fill a want that has been expressed by the extension and administration men for some time. It will consist of brief notes on new books, new bulletins and important articles in technical magazines to which the members of the Society do not usually subscribe. There will be no attempt to review bulletins which are simply reproductions of standard information adapted to different provinces. The idea is to review bulletins which have an application over the Dominion or which bring out some new information or new method of presenting information. The amount of space given to this feature will vary from two to four pages, depending upon the make-up of the magazine for the month and the amount of material on hand. The members of the Editorial Board have been requested to submit reviews from their respective fields, and others who feel that they have discovered publications which should be reviewed are requested to communicate with the Managing Editor.

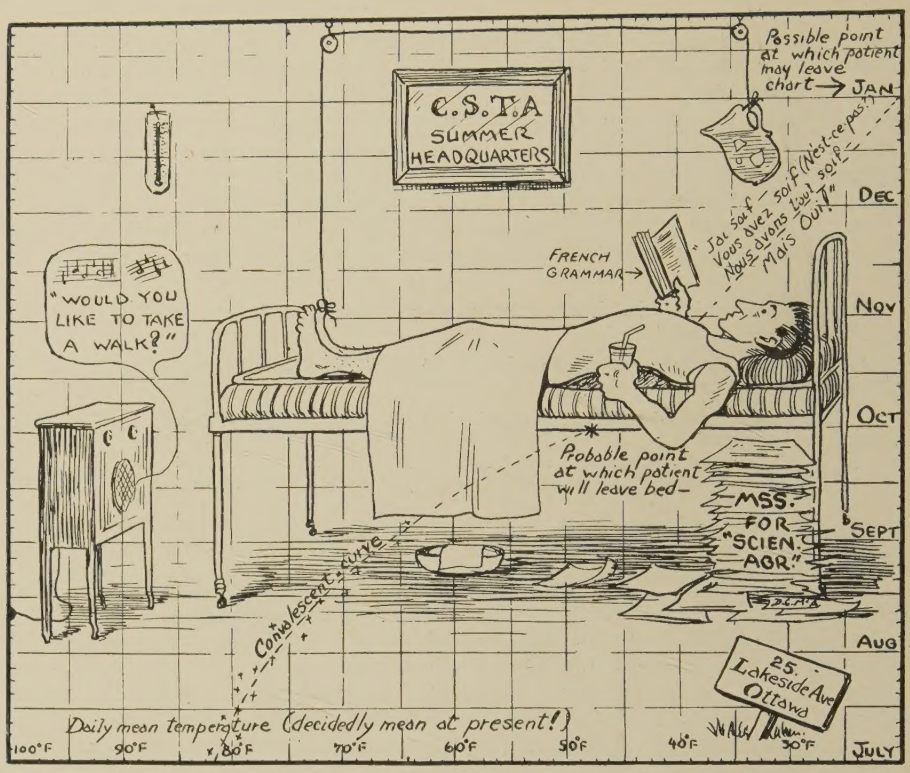

Figure 13. General Secretary Improving (?)

SUGGESTIONS ON THE PREPARATION OF CHARTS

(Not to be taken too literally)

Following the regulations given in this issue of *Scientific Agriculture* respecting the submission of manuscripts we present herewith a few suggestions to authors on the preparation of charts. The sample above has been perpetrated after consultation between the Managing Editor and our Staff Artist.

In the first place, a little human interest incorporated in charts would attract the attention of the reader, thus preparing the way for sustained interest followed by a desire to assimilate the information presented; in other words a sale would be made in the best modern manner. Charts illustrating the chemical analyses of numerous samples of soil, for example, might show the investigator in the act of scorching his fingers over a Bunsen burner. Of course, fingers get scorched occasionally in other type of investigation. A lot of apparently otherwise waste space on charts could be utilized to advantage if this type of illustration were adopted.

Keeping in mind that the C.S.T.A. is made up of many sections whose members can not possibly be familiar with the terminology of all sections, scientific names and technical terms should be marked by an asterisk and explained in footnotes, as, for example, in the above chart.*

We also bring forward with pride the suggestion (illustrated above) of a theme song for each chart. This is but a natural outgrowth of that tendency of modern civilization whereby we rise, bathe, shave, dress, eat, travel, work, loaf, get ill and recuperate to the strains of ancient and modern classic and unclassified gems. We claim priority, however, for the suggestion that charts be accompanied by appropriate selections. For example, the apiarists could use "The Song of the Bumble Bee' by Rimsky-Korsakov, while one of those economic charts showing the ups and downs of the market would gain in effectiveness if accompanied by that snappy item, 'Every little movement has a meaning all its own'. The animal production men have been chanting for some time, "The old grey mare, she ain't what she used to be' and should now present us with a chart to the same tune but singing, 'she's better than she used to be'. No doubt other appropriate selections could easily be found.

*J'ai soif etc.; I'm thirsty, you're thirsty, we're all thirsty.